EUGENICS, GENETICS AND THE FAMILY

VOLUME I

SCIENTIFIC PAPERS OF THE

SECOND INTERNATIONAL CONGRESS OF EUGENICS

HELD AT

AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK

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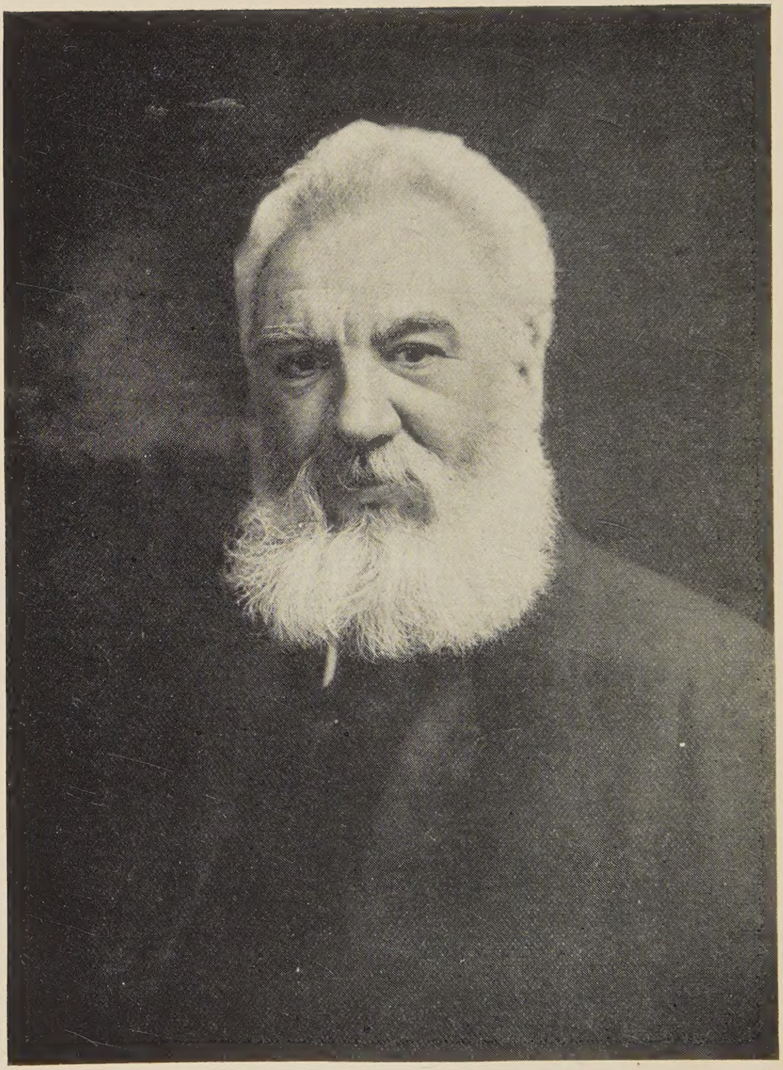

Alexander Graham Bell

Honorary president of the Second International Congress of Eugenics, and pioneer investigator in the field of human heredity.

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PREFACE

This volume contains a series of addresses and scientific papers given at the Second International Congress of Eugenics held in New York in September, 1921. The three addresses speak for themselves, and are intended to make a popular appeal. The scientific papers are in the field of heredity and family studies. It is distinctive of eugenics that it is an applied human science, in this respect like medicine; but one dealing with the larger biologico-social aspects of the human race. To-day, as never before, we realize that at the bottom of real social progress lies the germ plasm—the chromosome complex which, during all these eons, has been controlling the progress of the organic world; created the precursor of man and, all hidden and unknown, has directed human evolution with a certainty that has made all human endeavors in this direction almost negligible. It speaks for the breadth of geneticists that, while recognizing that there is much said and done in eugenics that is not scientific, they were glad to contribute their special knowledge to a subject of such importance for humanity. Through this contribution which they have made, the methods and some of the results of genetical research will become better known to those who are applying eugenical principles. Pages 29 to 242 contain the results of some of the most advanced and best known investigators in genetics. They give an insight into the phenomenal progress that has been made in the past twenty years in the field of heredity.

The particular field of human genetics has methods of its own, just because human matings are not under the control of the geneticist. One of these distinctive methods is, accordingly, the collection of family pedigrees, to learn what sorts of matings have produced particular kinds of progeny, and, conversely, what kind of progeny have resulted from particular matings, bringing together particular kinds of gametes. So the analysis of human families is of prime importance in eugenics, and the present volume contains, pp. 243–390, reports on biological researches on families and the results of human matings. Here are discussed data on differential fecundity, on inbreeding, on special strains, on particular families, on experiments in the control of human matings, on family traits in relation to social conditions.

For the publication of this volume, there is first of all to be thanked the contributors to it, who have given it its great intrinsic value, and who have

cheerfully responded to the requests of the Publication Committee. But these efforts and good will alone would not have sufficed, since no publisher could be found who would undertake the manufacture of the book without financial guarantees. After some delay, these guarantees were secured and we are here expressing the thanks that all must feel to the special contributors to the publication fund: Dr. Frederick Adams Woods, Mrs. E. H. Harriman, Mr. Alexander B. Coxe, Mr. Charles W. Gould, and Mr. Madison Grant. Thanks are due also to the Messrs. Williams & Wilkins Company who have assumed no little risk in undertaking the manufacture of these volumes, and who have spared no pains to publish the work promptly and in attractive form. Finally mention must be made of the painstaking work of Miss Luella H. Smith who prepared the index to the volumes.

ADDRESS OF WELCOME

HENRY FAIRFIELD OSBORN
American Museum of Natural History

I doubt if there has ever been a moment in the world's history when an international conference on race character and betterment has been more important than the present. Europe, in patriotic self-sacrifice on both sides of the World War, has lost much of the heritage of centuries of civilization which never can be regained. In certain parts of Europe the worst elements of society have gained the ascendancy and threaten the destruction of the best. At this moment we welcome the sound and highly trained judgment of Major Leonard Drawin, leader of the eugenics movement in Greater Britain; of Dr. Lucien March, the leading statistical authority of France, also leader in the eugenics movement and senior representative of the eugenics movement there; of Dr. Lucien Cuénot, foremost student of the science of heredity in France; of Dr. G. V. de Lapouge of France, the leading authority on racial anthropology and earnest exponent of practical eugenic measures by the government. Dr. Jon Alfred Mjøen of Norway is the leader in the vigorous movement of race hygiene in Scandinavia. Contributions are welcomed from other representatives of Great Britain, of France, of Italy, of Belgium, of the new Republic of Czecho-Slovakia, of our sister Republic of Cuba, and of South and Central America. The leading students of heredity, of statistics, of anthropology, and of eugenics in the United States are here to welcome their confrères from abroad.

To each of the countries of the world, racial betterment presents a different aspect. To the five countries most closely engaged in the recent fratricidal conflict the financial and economic losses of which we hear so much are as nothing compared with the spiritual, intellectual, and moral losses which each has sustained. In the Scandinavian countries, which kept out of the conflict, and to a large extent in the United States the case is different. In Scandinavia, which I have recently visited, it is largely through the active efforts of leaders like Mjøen and Lundborg that there is a new appreciation of the spiritual, intellectual, moral, and physical value of the Nordic race, and that a warning is being given that it must not be too severely depleted by emigration. Nearly half that race is now in the United States.

In the United States we are slowly waking to the consciousness that education and environment do not fundamentally alter racial values. We are engaged in a serious struggle to maintain our historic republican institutions through barring the entrance of those who are unfit to share the duties and responsibilities of our well-founded government. The true spirit of American democracy that *all men are born with equal rights and duties* has been confused with the political sophistry that *all men are born with equal character and ability to govern themselves and others*, and with the educational sophistry that education and environment will offset the handicap of heredity. South America is examining into the relative value of the pure Spanish and Portuguese and of various degrees of racial mixture of Indian and Negroid blood in relation to the preservation of their republican institutions.

In my recent tour through Belgium and all parts of France, I was deeply impressed with the very slight convergence produced by 12,000 years of similar environment and a thousand years of similar education upon the three divergent races of which France is composed,—the Mediterranean, the Alpine, and the Nordic.

The constructive spirit of this Congress is to discover the virtues and the values of each of these minor divisions of the human species, as well as the needs of the major divisions, known as the Caucasian, the Mongolian, and the Negroid. The reason that these races are so stable and maintain their original character so stoutly is that the most stable form of matter which has thus far been discovered is the germ plasm on which heredity depends. This outstanding fact of heredity will be brought out in the First Section of the Congress. As a palæontologist and geologist, as well as something of a biologist, I find no form of matter so stable in nature as that on which heredity depends—consequently the selection, preservation, and multiplication of the best heredity is a patriotic duty of first importance. In the selection of the best we should know no prejudice. If we extenuate nothing, we write down nothing in malice. The 500,000 years of human evolution, under widely different environmental conditions, have impressed certain distinctive virtues as well as faults on each race. In the matter of racial virtues, my opinion is that from biological principles there is little promise in the "melting pot" theory. Put three races together, you are as likely to unite the vices of all three as the virtues. This opinion, however, awaits the experimental proof or disproof which will be presented by researches such as those of Doctor Sullivan in the Hawaiian Islands. For the world's work, give me a pure-blooded Negro, a pure-blooded Mongol, a pure-blooded Slav, a pure-blooded Nordic, and ascertain through observa-

tion and experiment what each race is best fitted to accomplish in the world's economy. If the Negro fails in government, he may become a fine agriculturist or a fine mechanic. The Chinese and the Japanese have demonstrated in the history of their respective countries a range of ability in art, literature, and industry quite equal to our own in certain arts, and greatly superior to our own in other arts, like ceramics. Let each race consider its own problems and demonstrate its own fitness.

Our Fourth Section is devoted to the state. The right of the state to safeguard the character and integrity of the race or races on which its future depends is, to my mind, as incontestable as the right of the state to safeguard the health and morals of its people. As science has enlightened government in the prevention and spread of disease, it must also enlighten government in the prevention of the spread and multiplication of worthless members of society, the spread of feeble-mindedness, of idiocy, and of all moral and intellectual as well as physical diseases.

I would not anticipate the findings of any of the four sections into which the work of the Congress is divided, but I would express my opinion that the monogamous family, *i.e.*, one husband, one wife, is to be maintained and safeguarded by the state as well as by religion as a natural and hence as a patriotic institution. In Doctor Lowie's very able recent work, "Primitive Society," it is shown that in general the family is safeguarded; that the natural instinct so widely prevalent among all social lower orders of animals to preserve the family at all costs dominates the elementary morals of primitive races. It is not an exaggeration to say that many tendencies in recent social development, as distinguished from racial evolution, are against this natural mandate regarding the family. The wisdom of British biologists, expressed by Tennyson in his memorable lines:

> So careful of the type . . .
> So careless of the single life,

has been transmuted into the fatal reverse

> So careful of the single life
> So careless of the type.

The closing decades of the nineteenth century and the opening decades of the twentieth have witnessed what may be called a rampant individualism— not only in art and literature, but in all our social institutions—an individualism which threatens the very existence of the family; this is the motto of individualism: let us obey our own impulses, let us create our own standards, let each individual enjoy his own rights and privileges—for

tomorrow the race dies. In New England a century has witnessed the passage of a many-child family to a one-child family. The purest New England stock is not holding its own. The next stage is the no-child marriage and the extinction of the stock which laid the foundations of the republican institutions of this country.

It is questions of this kind which are being set forth before this Congress so that they may be disseminated among our people. Let us endeavor to discard all prejudices and to courageously face the facts. Recent works by Bury and Inge on human progress are regarded in some quarters as pessimistic. I do not regard them as pessimistic, because to my mind the pessimist is one who will not face the facts, and these writers, especially Inge, look at the worst as well as at the best. I regard an optimist as one who faces the facts but is never discouraged by them. The optimist in science is one who delves afresh into nature to restore disordered and shattered society. This was the constructive spirit of Francis Galton, founder of the science of eugenics. I trust it will be the keynote of this Congress. To know the worst as well as the best in heredity; to preserve and to select the best—these are the most essential forces in the future evolution of human society.

MAJOR LEONARD DARWIN

Son of Charles Darwin, and president of the Eugenics Education Society of Great Britain, also head of the British delegation to the Second International Congress of Eugenics.

THE AIMS AND METHODS OF EUGENICAL SOCIETIES

LEONARD DARWIN

President, Eugenics Education Society, England

International congresses are organized no doubt mainly with the object of enabling workers in the same field both to become personally acquainted with each other—a far-reaching benefit—and to exchange information and ideas. We who have just crossed the Atlantic have come to a land in which many notable institutions have long been engaged in the study of biology and genetics, these being the pure sciences on which the applied science of eugenics is based, and where human racial problems have also long been keenly investigated. So much has been done in all these directions here that when I was honored with an invitation to address you I felt great difficulty in selecting a subject which I could discuss with any reasonable prospect of promoting our common aim, namely, the improvement of the racial qualities of future generations. It is, however, not only scientific information which we can now profitably exchange one with another, but also our actual experiences; and, as I have been for ten years president of a British society for the promotion of eugenics, it occurred to me that it might interest you to hear something about our aims, our methods and our difficulties. I look forward to the time when eugenical societies will exist in all populous centers, their work being to strive to build up a social superstructure on the scientific foundations laid by central organizations engaged in biological and eugenical research. Whilst these much needed societies are passing through the period of their adolescence, we may be sure that they will not be without their growing pains and their difficulties; and these difficulties will certainly be more easily overcome if clearly realized in advance. I hope, therefore, that existing societies will not scruple to air their troubles in public!

When an association is being created with any social object in view, a demand is likely to be made for a clear and rigid definition of the policy which is to be promoted by it; and from such demands may arise not only the first juvenile ailments of eugenical societies, but also occasional internal inflammations later in life. Now I was recently asked to state once again in broad and general terms what are the aims of my society, such a statement being needed not so much for our own information as to enable us to make

our position more clear to the general public. The main difficulty in replying to this request lay in the fact that experience has taught us that attempts to decide in detail exactly what may be advocated and what should be condemned by eugenists are more likely to do harm than good by unduly restricting eugenic activities. A choice has always to be made between a smaller society with narrower aims and a larger society tolerating wider divergences of opinion; and although both plans have their advantages, yet in a young and growing subject like eugenics care should be taken not to injuriously hamper future liberty of action by too rigid definitions of policy. What seemed to me to be needed was a eugenic sign post, with arms pointing, not to every by-path, but to the various main roads along which our society should strive to advance; and the conclusions I then reached I now repeat in the hope that they may prove to be of some interest to a wider circle of friends.

The first words which I uttered as the president of my society ten years ago were that heredity should be its guiding star, and in that opinion I have never faltered. A good deal of progress has been made since that date, and now the man who calls himself well educated is as a rule beginning to have some dim idea that all human beings are the product of two factors, heredity and environment, and that consequently to both of them some attention should be paid. Now if a eugenical society accepts only one of these factors, namely, heredity, as the foundation on which all its operations ought to be built, its members should as individuals most clearly emphasize the fact that all those who are striving to improve human surroundings have their warm sympathy. Of course eugenists cannot approve of such measures as would injure mankind as a whole, the future as well as the present being taken into account; but, putting that possibility aside, we personally should give our blessing to many reforms which eugenical societies do not help to promote. We see as clearly as anyone that to take steps tending to produce in the future a race with the best possible natural qualities would be a futile proceeding unless we hoped that when such a race did appear great care would be taken to give to it good surroundings. If eugenical societies confine their attention exclusively to heredity, it is only because so many other societies think only of environment.

It is true that sometimes it may be necessary to indicate that the high hopes entertained by reformers of to-day are not justified by past experiences. It may be said with only a microscopic divergence from the truth that all reforms since civilization began have been based on attempts to improve human surroundings; and we may ask those who found their hopes for the future only on changes being made in environment to con-

sider how much has thus been accomplished since history began. As to our highest moral ideals, is it not true that for the most part they have been promulgated in certain eastern countries ever since the dawn of civilization? How do we compare in intellect with the inhabitants of ancient Greece two thousand years ago? With a knowledge of the delights of country life, can we look on our slums with anything but shame? Do we not blush to talk of peace on earth and goodwill towards men whilst remembering what has happened during the last seven years? And, in view of all this, have we any right to assume that improvement of environment will do more for mankind during the next two thousand years than it has done since the days of Plato? Reformers who look only to surroundings should consider well the foundations on which their projects are based before pointing the finger of scorn at the believers in heredity. Eugenics has been called a dismal science, but it should rather be described as an untried policy. Eugenics indicates a new method of striving for human welfare which, if combined with an equal striving for improvements in human surroundings, more truly justifies a hopeful outlook than anything which has yet been tried in the whole history of the world. More hopeful, that is, if the roads to which our eugenic finger post is pointing are not as studiously avoided in the future as they have been in the past.

The eugenic sign post which we wish to erect should, in my opinion, have three arms on it, pointing to three main lines along which an advance should be pressed forward. In the first place the public should be made to realize more and more fully what a potent influence heredity has on the fate of all nations. In the second place efforts must be made to ascertain and to make known the rules by which each individual ought to strive to regulate his own conduct in regard to parenthood in accordance with the laws of heredity in so far as they are now surely known. Lastly, the action which the state should take in order to stimulate and to enforce conduct productive of racial progress must be considered, a line of advance to be advocated, however, with great circumspection when compulsion is concerned. Our aim must be to advance along all these three roads simultaneously and continuously.

The laws of natural inheritance supply a means of predicting in a measure the qualities of offspring when the qualities of their parents are known; and if any society accepts heredity, not as its sole guide, but as a light ever to be held in view, it is in fact intending to rely to some extent on these laws of natural inheritance when attempting to forecast the results in the future of our actions of to-day. Genetics is the pure science which deals with heredity, and genetics is, therefore, the very foundation on which the super-

structure of eugenics is being built. The students of genetics will, however, I am sure, all agree that a vast amount of research is needed before they will be able to rest satisfied with the knowledge they have acquired, supposing it to be possible that such a state of contentment will ever be reached. Now it is impossible to conduct the needed breeding experiments on human beings, and genetic research must be largely concerned with the lower animals and with plants; whilst eugenics is primarily concerned with man alone. Then again eugenics must include the study of many social and economic problems which lie quite outside the sphere of genetics. The pure science of genetics and the applied science of eugenics do, therefore, cover different fields, though the boundary between them is ill defined and movable; and in both fields further advances are urgently needed. For these reasons it seems to me—though here opinions may differ somewhat—that the main aim of eugenical societies should now be, whilst leaving geneticists to cultivate their own ground, to formulate a sound eugenic policy based on existing genetic knowledge, and then to promote the translation of every advance in eugenic theory into general practice. If we eugenists rely on scientific experts for the laying of our scientific foundations, then we shall be able to devote our main energies to the advocacy of reforms tending to promote racial progress and to considering how wide may be the area over which such reforms can be justifiably extended.

With regard to much of the research work which is so urgently needed, most eugenical societies will indeed have no option but to leave it to others or to leave it undone; because in many lines of enquiry a well equipped laboratory and a highly skilled staff are essential for success. Certain investigations, which need no special apparatus, however, could be carried on anywhere. Moreover, the scientific material as received from geneticists often needs to be thoroughly discussed by eugenists in a scientific spirit before being applied to human affairs; and we must not rely wholly on genetic research for the supply of scientific material on which to build. Wealthy patriots in all countries will doubtless from time to time perceive that by their wealth they might help to promote the acquirement of that knowledge on which racial progress must depend in the future. A strong central society might in such cases play a useful part in suggesting various directions in which, with their aid, advances of great value could at once be made; as well as being ready, if so desired, to act as agents by whom the investigator would be selected and employed, care being taken not to hamper him with undue control. The more liberal the benefaction the more fundamental and far-reaching might be the researches thus undertaken,

and the greater the ultimate benefit to mankind. Your endowments in America are so magnificent that you may not fully perceive how much they are needed elsewhere.

As to the first of the suggested lines of advance, namely, as to getting into direct and immediate touch with the public with the hope of spreading abroad a general knowledge of the laws of natural inheritance, this knowledge should form the basis of all the arguments brought forward at public lectures on eugenics, that is, at lectures not forming part of any extensive series. It is indeed in laying this foundation of scientific truth that speakers on such occasions encounter their greatest difficulties; for many prejudices arising from ignorance have to be overcome. For example, those who do not acknowledge to themselves that men differ greatly from each other in their inborn qualities, cannot be made to realize the extreme importance of paying attention to heredity in regard to social questions; and the acknowledgment that we do not start even in the race of life will be hindered by a disinclination which we all feel both to regard any human disabilities as being incurable and to own that other individuals may be greatly superior to ourselves. As to the facts on which the scientific theories of heredity are based, it is worse than useless to attempt to give them in detail at single lectures; for lecturers should remember that on such occasions they cannot hope to do more than leave an enduring *general* impression on the minds of their audiences. Except in systematic courses of study, much must always be both stated and accepted on authority; for to fully justify all the beliefs of eugenists would require months rather than days. "It is hardly possible," so my father declared, "within a moderate compass to impress on the minds of those who have not attended to the subject, the full conviction of the force of inheritance which is slowly acquired by rearing animals, by studying the many treatises which have been published on the various domestic animals, and by conversing with breeders."[1] If this be so, the public can only learn how to give to natural inheritance its proper value by acquiring information at second hand; and yet to make any statement acceptable to audiences, it must be in some degree endorsed by their own reasoning powers. It is on this account that allusion to the breeding of domestic animals becomes almost a necessity in public lectures on eugenics, for the wisdom of attending to breed in the case of cattle and dogs is universally admitted. Great care should, however, always be taken to indicate that, though our experiences in the stockyard enable us better to understand the laws of natural inheritance,

[1] Animals and Plants under Domestication, Darwin I, pp. 447–448.

yet our reliance on these laws carries with it no implication whatever that the methods of the animal breeder ought to be introduced into human society. It should in fact be most strongly emphasized that nothing which we advocate is contrary to the highest religious ideals. This is, however, rather a digression; for I am not here to instruct lecturers how to lecture. All that I now wish to insist on is that, by means of lectures to audiences of all kinds, the endeavor to spread abroad sound impressions concerning the force of natural heredity and the enormously important influence which it has in deciding the welfare and the destiny of nations should form a prominent part of the programme of all eugenical societies.

The title selected for the British Society by its founders was the Eugenics *Education* Society, and certainly they had excellent reasons for thus emphasizing the educational aspects of the eugenic campaign which they were inaugurating in my country. No class of the community is more important to interest in racial problems than teachers of all grades; because the ideas of the youth of to-morrow will depend so largely on the opinions of the teachers of to-day. But teachers must be taught before they can take a thoroughly intelligent interest in racial questions; and for this reason it is of primary importance that biology should be given adequate recognition in the curricula of all colleges where teachers are trained. Our educational aspirations could not, however, be completely satisfied in this way; for to finally succeed in the first of our main aims, namely, the spreading abroad of a general knowledge of the laws of natural inheritance, natural science must be given a far more prominent place than at present in the courses of studies of all schools and colleges. No doubt there are many who now regard our efforts with great distrust; but those who feel thus should remember that the better and the more wide-spread the teaching of biology, the more certain would it be that any eugenic errors would be detected and their harmful influence prevented. Moreover, if we want progress in scientific research to be both rapid and on right lines, it is important that a considerable number of students should be thoroughly trained each year in genetics, or that more undergraduates should specialize in natural science at our universities than at present. Eugenics has a long struggle before it, and all these methods of laying educational foundations for future progress should certainly come within the scope of the efforts of eugenical societies.

Passing on to the second of the main lines along which eugenical societies should strive to advance, what we want to know is the rules which ought to guide each individual in deciding on his own voluntary actions in all matters relating to racial progress. The attempt to ascertain the precepts by means

of which each one of us should strive to regulate his conduct in questions connected with parenthood obviously involves the consideration of a number of ethical, racial and economic factors; for, in regard to any proposed line of conduct, we have to weigh in the balance as well as we can its moral effects, the immediate material advantages or disadvantages to the family and to the state which are likely thus to arise, and the benefits or injuries which it will confer or inflict on the race in the future. Even if these problems be approached in a calm and scientific spirit—and in this respect eugenical societies should strive to set a much needed example—even then it will be exceedingly difficult in most cases now to arrive at precise conclusions. We must not attempt in the present state of our knowledge to lay down rigid rules of conduct, but only to suggest general guiding principles; though we may hope that with every advance of science it will be possible more and more clearly to indicate what each individual ought to do and what he ought to avoid. As an illustration of the difficulties involved in these problems, consider the case of a contemplated marriage when both families thus to be connected are characterized by some degree of ill health. Now it would only be persons endowed with high moral qualities who would be likely to obey any self-denying ordinance in regard to marriage and whose fertility would, therefore, thus be diminished. Might we not, by condemning marriage in such cases, tend to breed out the most valuable of all human attributes, namely, the desire to do right? Again if insanity were the family trouble in question, this being one of the most grievous of all human ailments, we now know that it is sometimes the result of disease and probably in such cases not heritable, whilst other types certainly do run in families. What are we to do in the face of such doubts and difficulties as these? Are we to admit our incapacity to meet the situation? Certainly not, for the history of scientific research clearly proves that what to-day appears like an impenetrable barrier to further progress will probably to-morrow be regarded rather as a useful stepping stone for a further advance. Doubtless we have difficulties ahead of us, which must be faced with patience; but we should take note of these obstacles in our path mainly as emphasizing the need for societies where such guiding rules for voluntary conduct in relation to parenthood as are warranted by existing knowledge and by present needs will be wisely and temperately discussed.

A comparatively new subject like eugenics is apt to arouse prejudices and to give opportunities for misapprehension; and it sometimes seems that what is now most needed on the part of eugenical societies in regard to voluntary actions is that they should make clear what they are *not* recommending. We have been accused of wishing to abolish love altogether as a

guide to conduct; but this is false. What we desire is rather to purify love, or to clear away all those harmful influences which so often attach themselves to it. Certain American investigations indicate that the ideals which naturally dwell in the minds of young people in regard to the qualities of the mates to whom they would wish to be connected in marriage are on the whole fairly sound, and that these promptings if followed would generally lead to unions beneficial to the race. But the desire for wealth, the wish to rise in the social scale, and, some would add, too great attention to personal appearances, often make the choice of a mate far worse than it would have been if these natural ideals had been given full sway. In passing I must, however, put in a racial plea for good looks on the ground that they are apt to be associated with good health; a plea which I hope does not spring from a mere masculine weakness on my part. Be that as it may, love is doubtless to a large extent aroused by advantageous moral and mental qualities; and, in so far as that is the case, it forms the firmest foundation on which to base a eugenic policy. Much can be done to help to lay this foundation by promoting suitable opportunities for the meeting of young men and maidens; by judiciously encouraging intercourse between our children and worthy friends of the other sex, from amongst whom worthy mates are not unlikely to be selected; by stimulating a pride of family in so far as dependent on character and performance; and, above all, by fostering the growth of all that is noble in the ideals of the adolescent. Never make a close friend of a person one can not respect is, I believe, not only a helpful rule of life, but also a useful way of setting an example to the rising generation. But here a possible racial danger must be noted; for an injudicious pursuit of the policy here suggested might make the high-minded become too particular and therefore less likely to marry than their more ordinary companions, with obvious dysgenic consequences. Pure love between the sexes should be proclaimed as the noblest thing on earth, and the bearing and rearing of children as amongst the highest of all human duties. Some risks ought to be run in order to secure these joys and to fulfil these duties; and Cupid may well remain a little blind to all minor defects. To promote these ways of regarding sexual problems and to show how often the moralist unknown to himself is in effect striving to better the racial qualities of future generations come well within the scope of our endeavors.

Though we have seen that as knowledge increases so the difficulties of deciding on rules of personal conduct will diminish, yet it is certain that these difficulties will ever remain very formidable. We may now boldly assert that when the heritable defects of many members of a family are

very serious, those belonging to it should not become parents; but how serious must these defects be before being regarded as a bar to parenthood? It will never be possible to draw as sharp a line of demarcation as that between sheep and goats when marking off from the general population those in whom parenthood would be a moral offense. Because of this impossibility, it may come to be held that the size of the family should vary with the innate qualities of the parents; but how is this relationship between fertility and transmissible characteristics to be determined? Then, again, many who take no thought concerning racial questions now hold strongly that it is wrong to bring a child into the world without a reasonable prospect of its being able to live a life up to a certain standard of civilization. But what should be the standard adopted? In large numbers of cases the cause which has prevented the winning of a "standard" livelihood, however we may define that term, has been some inborn defect, or defect which would in a measure be passed on to the next generation. Teach those not living up to standard to regulate their conduct with due regard to the welfare of any children who may or may not be born in the future, and many would limit their families on this account; with the results that these harmful innate defects would appear less frequently in future generations. Is it not, therefore, of great importance that some attempt should be made to ascertain what standard of living does justify parenthood? Again it is even more important that it should be widely felt that it is morally wrong to limit unduly the size of the family when parents are up to "standard" in all respects; for it is essential for the welfare of mankind that the seed of this good stock should not be lost to posterity. Eugenical societies should, in my opinion, steadily keep in view the necessity of trying to solve all these intensely difficult problems; problems which need the joint consideration of the eugenist, the geneticist, and the economist for their solution. But as for our advice of to-day concerning personal conduct in regard to procreation, we can say little more than that moral principles must always be kept in the foreground, and that, for the rest, trust must be placed in common sense and a wise doctor.[2]

To whatever extent success may attend our efforts to lay down rules for personal conduct in regard to parenthood, to that extent we shall have succeeded in deciding on the directions in which we wish to advance in these matters. Such decisions will, however, prove to be but a very uncertain indication of the extent to which the state should endeavor to

[2] I assume that the doctor has studied genetics, which is unfortunately not always the case.

promote or to enforce obedience to these rules; this being the subject to which we must now turn our attention. By promoting uniformity of conditions and by checking individual initiative, the state often retards progress; and, besides affecting those intended to be affected, governmental action nearly always produces on other persons various consequences which were unforeseen and which are never fully realized. Whatever may be our political opinions, we nearly all of us agree that these are dangers which must be taken into account when contemplating state control over the individual. These are, however, large issues which some will regard as lying outside the proper scope of eugenic considerations; whilst the point which I especially wish to emphasize in this connection is one definitely related to the actions of eugenical societies. In my opinion our societies ought to be ready to encourage *discussion* on all proposals for relevant reforms, whilst they should be cautious in the present state of our knowledge in actually recommending *governmental interference.* If discussion be not bold, progress will be slow; for a nation can not grope its way quickly to the front in the darkness of ignorance. If action be too bold, progress will also be slow; for the wrong road will often be taken. In matters of conduct we should balance the *probability* of good or evil arising from the action proposed to be taken, as against the *magnitude* of the good or evil if it does arise. The smaller the chances of failure, the smaller may be the benefits hoped to be attained. The probability of harm resulting from the mere discussion of any reform would usually be very small, even if that reform would be very harmful if adopted. On the other hand, the possibility of benefits arising from the discussion of reform is almost equally obvious whether the proposed legislation would in fact be beneficial or harmful. To take a single example, there are strong differences of opinion as regards sterilization; but all may hold that by open discussion true conclusions would most likely be reached. The advocates of sterilization of course wish to have this subject brought to the notice of the public; whilst its opponents must admit that they will be more likely to promote than to retard its introduction by, as it were, burying their heads in the sand like the ostrich and by refusing to favor the creation of opportunities for openly stating their objections to it. It is indeed nearly true to say that every subject may be openly discussed with advantage *provided the occasion be properly chosen* and it is in this spirit that eugenical societies should, in my opinion, conduct their proceedings.

In all human affairs we are constantly being compelled to take opposing considerations into account and to adopt compromises, and I think that I ought not to be accused of inconsistency if I now turn round and show why

eugenical societies ought not to be too timid in regard to legislation. As to your middle-aged Anglo-Saxon, and I am only speaking for my own country, there is hardly anything which he dislikes so much as having to change his opinions; and from this weakness men of science are by no means exempt! Here is a barrier which will stop any half-hearted advance on the part of eugenic reformers! To the students of natural sciences, at all events, we can suggest that Nature's plan seems to have been to stamp out of existence all organisms which fail to fill the places she assigns to them, and this without regard to the sufferings thus caused or to the superiority in many respects of large numbers of the individuals thus eliminated. By adopting rational methods in human affairs, much can be done and much ought to be done to prevent human beings from being enforced to sufferings similar to those which animals in the wild have to endure because of that struggle for existence to which they must submit; but nevertheless we should not be quite blind to the example set us by Nature in her readiness to sacrifice the individual for the sake of the race. Unfortunately it will be our politicians who will mainly settle how far the teachings of science shall be made to affect legislation; and this they will be apt to do with little reference to the opinions of experts and largely in the hope of catching votes. But the votes of future generations can not now be caught, and their interests will, therefore, be likely to receive but scant attention in all democratic countries. Governments which depend on the suffrages of the people are of necessity always somewhat timid in regard to unpopular reforms; and until eugenics becomes popular—when will that be, I wonder!—there is not the slightest chance of eugenic reform moving forward with too rapid strides. Eugenists must lead the advance in racial questions, and our societies must remember that nothing is more fatal to leadership than a show of timidity. We should discuss long and freely, and when we do advance, advance boldly.

Legislative reforms can seldom be effectively promoted or steadfastly maintained unless they are sanctioned by the general opinion of the citizens concerned; and, on somewhat similar grounds, eugenical societies would be wise to avoid taking corporate action in regard to legislation unless the proposal in question has the nearly unanimous approval of their members. The neglect of such warnings has led to the disappearance of governments and to the disruption of societies! When legislation does not involve compulsory interference with the liberty of the individual, there is comparatively little danger of internal friction being caused by its advocacy; for unanimity in such circumstances is both more probable and less necessary than when compulsion is involved. As examples of legislation of general application

producing beneficial racial effects, certain reforms in regard to taxation might be mentioned. My Society took an active part in the agitation in favor of such alterations in the assessment of income tax as would make the burden of taxation fall less heavily on parents of families and more heavily on bachelors and the childless *in the same stratum of society*, the object being to increase the birth rate of a useful class of the community. As to legislation involving interference with individual liberty, here also unanimous support can be obtained if the racial advantages are sufficiently obvious. For example, there was no dissension whatever in my society when we moved in favor of the Mental Deficiency Bill, a bill which authorized the segregation of the feeble in mind, that is to say, their detention in comfort under carefully safeguarded conditions. But until unanimity in the ranks of a eugenical society in regard to such compulsory measures is obtainable, their discussion only is to be recommended. Personally I should like to see practical steps at once taken for lessening the fertility of habitual criminals, of hopeless wastrels, and of the grossly unfit generally, and others doubtless wish to advance in other directions; but we must have patience. My object for the moment is not, however, to attempt to survey all the roads by which advances may be made in future, but rather to consider what should be the broad principles of strategy which should guide eugenical societies in the long fight before them in their attempts to promote racial progress.

Thus I have dealt with the *objects* which eugenical societies should strive to attain rather than with the *methods* of attaining the ends desired, the reason being that I have little novel to suggest in regard to methods. With the view to the advancement of scientific knowledge and the elucidation of eugenic problems, my society holds periodical meetings at which addresses are delivered or questions debated. In our *Review* these addresses are often published, and we there also try to give impartial accounts of current eugenic literature. We maintain a library, and give advice to readers. We keep in touch with foreign societies, and it has been an especial pleasure to us to give all the assistance in our power to the American committee which has so admirably organized this Congress. As to activities definitely undertaken for the purposes of propaganda, the following may be mentioned: the delivery of lectures to audiences of various types, including social clubs, debating societies, educational conferences, summer schools for teachers, and, during war times, soldiers in camp and barracks; the organization of summer schools dealing largely with eugenics; the sending of deputations to government departments; and of letters to the press. To take one example in detail, after a thorough enquiry

concerning the incidence of our income tax, a letter was written to all members of Parliament, and at a later stage amendments to the Finance Act were proposed by members at our suggestion, and were rejected! The next step, a direct result of this agitation, was the appointment by the government of a royal commission on the income tax before which I gave evidence on behalf of my society. Several of the recommendations of that commission, representing a step forward in the direction desired, were subsequently adopted and became law. Thus by steady persistence on well thought outlines a society may be able to produce material effects in many directions. As a last word about the doings of my own society, I must be allowed to mention a dinner followed by an address, held on February 16 in each year. In this way we yearly remind ourselves on the birthday of Sir Francis Galton that to him we owe the opening of the eugenics campaign in England.

What I have tried to do in my address today has been to give some indication of the difficulties likely to be encountered by youthful eugenical societies; difficulties which, we have seen, may come from many quarters and in many shapes. Questions connected with both sex and personal liberty have to be dealt with by eugenists, and these are topics especially liable to give rise to strong feelings. Even when the opposition thus aroused is quite unreasonable, we should, however, always remember that the sentiments underlying this opposition are often in many respects highly commendable, and that to openly acknowledge where others are in the right is often the best way of getting a hearing for ourselves. The most formidable foe we have to meet is ignorance; and here again it is wise to admit that the ignorance is not all on one side. With every growth in our knowledge of biology and sociology we shall be able safely to enlarge our programme, and we should make it clear that our discussions of to-day are often tentative and do not always indicate the directions in which we shall advance to-morrow. As to the ignorance of our opponents, it can only be overcome by patience, perseverance and above all by never concealing such doubts as are still felt. Unfortunately it must be admitted that even perfect knowledge, however widely held, would not make our path quite smooth, human nature being what it is; for the want of attractiveness of our programme is largely due to the fact that we are looking to human welfare in the more or less distant future and not to present-day comforts. Most men in their march through life are hoping either for personal distinction as a reward for their exertions or for quick returns on their investments; neither of these benefits is to be obtained in the eugenic market. You can easily enough get your forests cut down and the timber sold for an immediate

profit; but the planting of slow growing trees, which will not be worth felling till most of us are dead, is a less attractive venture, though more beneficial to the nation. The reforms which the eugenist wishes to plant would certainly bear excellent fruit in due course, even though much of it would only be gathered by our children and our children's children. Then again your business men not seldom try to sell their goods by running down the wares produced by their rivals, an inexcusable proceeding in so far as merely an outcome of greed and jealousy. Now this same competitive spirit is far too much felt in social work, and I fear we eugenists have often aroused opposition by unnecessarily running down reforms dependent on changes in environment. Let us rather strive to show that there is plenty of open ground over which reformers of all kinds can strive to advance simultaneously and harmoniously; and let us all recognize that jealousy is one of the commonest and probably the most insidious of all human failings. The claims of this generation and of posterity are doubtless sometimes antagonistic, and the genuine difficulties thus arising must be openly faced and often met in a spirit of wise compromise. The main obstacles to be overcome by eugenists are, however, dependent on moral failings, and what we have to show is that we are engaged in a moral campaign, with human welfare in the highest sense as the goal for which we are striving.

Eugenics aims at increasing the rate of multiplication of stocks above the average in heritable qualities, and at decreasing that rate in the case of stocks below the average. But if the banner under which we are to fight should only have inscribed on it some such arid definition of policy as this, our defeat would be certain. We must prove that we are under the guidance of a noble ideal. We of this generation are responsible for the production of the next generation and, therefore, of all mankind in the future; and all in whom this sense of racial responsibility acts as a deep-seated sentiment, greatly affecting their action and their policy, are in truth guided by the eugenic ideal. The belief that man has been slowly developed from some ape-like progenitor came towards the close of the last century to be nearly universally held by thoughtful persons; this belief gave rise to a new hope that this upward march of mankind might be continued in the future; and out of this new hope sprang the eugenic ideal. This growing understanding of the past history of the world has led us to see that, if we are to imitate Nature in her methods, we must be content to advance by means of a long succession of small steps; just as rain falling in drops on the earth has slowly carved out mighty valleys in the hardest rocks. Without constructing wild Utopias, we must be content if some

little racial progress can be ensured as each generation succeeds another; for to work in this spirit is to work in harmony with the knowledge which gave birth to the eugenic ideal. Progress on eugenic lines will make mankind become continually nobler, happier, and healthier; whilst those who imagine that our sole aim is to make man a stronger animal or a better beast of burden are utterly ignorant of the meaning of the eugenic ideal. But science, whilst giving us good grounds for hope, also issues a grave warning concerning the danger of national deterioration resulting from the unchecked multiplication of inferior types. In the past many nations of the first rank, when apparently advancing without check on the path of prosperity, have begun to decay from unseen causes, and have in time so fallen from their high estate as to cease to count as factors making for progress. A determination that such a downfall shall not be the fate of his nation is a sentiment felt by every man who is animated by the eugenic ideal, an ideal to be followed like a flag in battle without thought of personal gain.

RESEARCH IN EUGENICS

CHARLES BENEDICT DAVENPORT

Carnegie Institution of Washington

Man is studying all phenomena. He has at last come to study himself. Not his diseases, not his language, not his customs merely, but also his more intimate self. Man is studying man as an animal, who varies in his traits, who selects his mates for better or worse, who has a larger or smaller number of children that are more or less healthy and live for a varying period. The races of man are being studied not merely to list their differences, but to find how those differences arose and how they are transmitted to progeny and how they intermingle. We are studying the laws that govern the distribution of traits in the family; we are studying the consequences of combinations of these straits in the instincts, interests and behavior of individuals. At last we are studying man as the product of breeding and as the subject of an evolutionary process. And we are studying the human germ plasm, its composition, its mutations and its mixtures.

And why do we investigate? Is not enough known to warrant *propaganda;* and should we not better organize for a campaign to change what needs changing? Alas! we have now too little precise knowledge in any field of eugenics. We can command respect for our eugenic conclusions only as our findings are based on rigid proof, a proof that is either statistical or experimental. Only as we are able to base our statements on scientific, quantitative data can we hope to carry conviction and not arouse contrary opinion. People do not have heated discussions on the multiplication table; they will not dispute quantitative findings in any science.

It is largely due to the extraordinary vision of Mrs. E. H. Harriman, the founder of the Eugenics Record Office, that in this country eugenics is more a subject of research than of propaganda. She maintained that we should be more concerned with knowing than with doing. Ascertained facts do not require propaganda.

It is sometimes asserted that research in eugenics belongs to the realm of applied science, and much of it does. But not all. There are fields of eugenical research, especially in human genetics, that are pure research in

as much as they are devoted to investigations that can not be carried out so well on any other material. For example, inheritance of psychological traits, of temperament and of sense perception.

In so far as eugenics may lay claim to being a science, it has not only a subject matter—but also a method of its own. In studying the genetics of the lower animals, we proceed by the method of control of matings. Now this method is obviously not applicable to man in modern civilized countries. It has to be replaced by the collection of the history of matings that have been already made and a study of their progeny. We replace the experimental mating of the geneticist with the principle that every fertile human mating is an experiment in genetics, and it is for us to record the result of the experiment. Some day, we may hope, human matings will be carried beyond the stage of experiment.

At present, then, the student of human genetics must collect data on human matings and their outcome. Of course, he must know, as thoroughly as he can, the genetic nature of the matings; so that he can give the probable genetic composition of the gametes. This means that he must know for the mated pair, the parent, uncles and aunts and their children. He can then check his findings by studying the traits of the children. Since the capacity of one man for collecting by himself is very limited, it is necessary to train observers to collect data. Hence has arisen the profession of eugenical field worker whose function it is to study through three or more generations and as analytically as possible all the members of an inter-generating group so that their probable genetic composition may be known. By gathering together in one depository a large quantity of carefully ascertained family data, the basis is laid for human genetical studies.

The history of the development of the method of eugenical field workers is not a long one. Dr. Alexander Graham Bell was one of the first to use it extensively in this country. He employed such field workers in his study of deaf mutes especially those of Martha's Vineyard, in the early eighties. The Reverend Oscar McCulloch made use of field workers in his study of the Ishmaelites in the nineties, and at the Vineland Training School such workers were employed before 1910. A large number of eugenical field workers (about 200) have been trained by the Eugenics Record Office since its beginning in 1910.

Besides trained field workers, numerous volunteers are in a position to contribute data. Thus, in 1884, Francis Galton distributed his questionnaires called "Record of Family Faculties," and over 150 persons volunteered to fill them out and return them to him for study. The Eugenics Record Office has made use of a similar questionnaire called "Record of Family

Traits," of which 4,000, of varying degrees of excellence, have been deposited in that office. Some of these "Records" are exceptionally valuable. It appears that many persons show the capacity for and interest in filling out such schedules excellently. A few others will take the pains to make a still more detailed analysis of the individuals of their families. Many of these records have to be considered as *finders* merely; as guides to further inquiries.

Additional records that are often of value are the printed genealogies and town histories, of which so many have been printed in this country, especially for the northeastern section. In addition, biographies, especially sets of biographies relating to members of a single family, will yield to the analyst of human traits data of the greatest importance. Finally all records—those of field workers, of volunteers and the printed records—must be indexed by name, place and trait so that their contents shall be readily available.

In inquiries into human genetics it is desirable, where possible, to breed experimentally mammals, if any are available, which show the same trait that we are studying in humans. This is often possible, and such study will afford a control of results gained on man. Thus have been studied hare-lip in dogs, fecundity in sheep, instincts in dogs, polydactylism in fowls.

In other studies the method employed will be that of accumulation of statistics, their tabulation and analysis. Thus we investigate mate selection, the relative fecundity and relative mortality of the various stocks and the effect on the germ plasm of a country of the different immigrant races.

Some of the results of analytical study of these eugenical data are fairly well established. A few clearly simple Mendelian traits have been found. Such is eye color in which brown is dominant over its absence. It is possible that in some cases additional factors may be present, but the rule serves as a first approximation. Dominant, also, appears to be curliness of the hair as contrasted with recessive straight. And there are various diseases and defects that appear either as simple dominants or recessives, such as abnormalities in number and form of fingers and toes, which are mostly dominant over the normal condition; various defects of the eye such as cataract, certain types of congenital deafness, various abnormalities of skin, and hair and nails.

Other, and probably many other, traits are due to multiple factors—so often this is true as to suggest the hypothesis that in mammals, as contrasted with insects, traits are genetically relatively complex. Thus stature and build and proportions of parts and pigmentation of hair and skin are dependent on multiple factors. Indeed, there seems to be evidence that

negro skin color is dependent upon two pairs of factors which merely reinforce each other.

Other traits are associated with sex in the remarkable fashion called sex-linked. That is, they are usually found only in the male sex and are inherited through the mother, though she, herself, is not affected. In such cases one usually finds male relatives of the mother who are affected. Such are color blindness, hemophilia and atrophy of the optic nerve. The facts of sex-linked heredity bring home, even to the layman, the lesson that heredity is a matter of the gametes; and that bodily appearance often gives no hint of the nature of the particular germ cells carried and, in so far, of what the inheritance shall be. The parents of an albino may have pigmented hair and skin, but both carry gametes which lack the capacity of forming pigment.

Our knowledge of the inheritance of these physical traits is sufficiently precise to be applied practically in cases of doubtful parentage. If the child, the known mother and both of the putative fathers can be seen, and some inquiry be made as to family stock of the three adults a decision can generally be rendered with a high degree of certainty ranging from 75 to 99 per cent. For usually there will not be one critical trait merely but several traits whose combined evidence will be overwhelming. Already the Eugenics Record Office has been asked to answer certain questions about the inheritance of traits in a case of a claimant who maintained that he was the son of a wealthy man who died without known heirs. As lawyers get more used to the idea of utilizing the advances of knowledge for evidence, it is probable that eugenical knowledge will be more and more called upon.

Not only of the physical traits referred to above but also of those of behavior we are learning the hereditary basis. It appears probable, from extensive pedigrees that have been analyzed, that feeble-mindness of the middle and higher grades is inherited as a simple recessive, or approximately so. It follows that two parents who are feeble-minded shall have only feeble-minded children and this is what is empirically found. It has been urged against this finding that it is improbable that so complicated a thing as full mentality depends upon only one factor. On the other hand, a consideration of the effect of internal secretions, of thyroid, of hypophysis and others leads to the conclusion that a brain with well differentiated intellectual centers may fail of complete development because of the absence of proper developmental impulses of glandular origin. Two persons whose brains are thus under-developed may differ greatly in their mental capacities, because they have fundamental nervous differences, just as seedlings of different species, while all alike under-developed, differ in certain specific

traits. Apparently one group of hereditary mental defectives is such because those who belong to it lack a single factor for an adequate developmental impulse.

Epilepsy, of the ordinary juvenile, dementing type, seems to be due, like feeble-mindedness, to a single developmental defect. Also, dementia præcox has been found by several investigators to be due to a similar cause.

But not only mental but also emotional states have a hereditary basis. The prevailing depressed mood appears to be due to a glandular condition that is determined by a certain developmental defect; and a prevailing excitability appears to be determined by a hereditary condition, which may be a tendency to excessive secretion of the suprarenal glands.

Moreover, the quality of our senses has a clear hereditary basis, as the still unpublished work of Dr. Hazel Stanton on musical families clearly shows. It appears from these studies that not only have great musicians an innate capacity for discriminating between closely similar qualities of pitch, intensity, time and for tonal memory but they belong to families with these innate capacities. Also, it has been shown that these capacities are not improvable by training; they depend upon our very constitution. Now we have evidence that persons who have these capacities enjoy exercising them. Those in whom the capacities are slightly developed get no pleasure from exercising them. We conclude that the reason why musical people are such is primarily because of their possession of inborn musical capacities. The musician is born, not made. From these principles certain deductions seem naturally to flow. A great color artist is one in whom the innate capacity for color discrimination is well developed and his family shows other examples of colorists. The sculptor has the hereditary capacity for form discrimination and that is why he finds his highest pleasure in the art. The author is one whose verbal machinery is especially perfect. The sailor is one who finds his greatest pleasure in the beauty of form of the vessel, or perhaps in broad horizons and distant lands; he is neither claustrophil, nor domestic. In general, our vocations, or at least our avocations, are determined by our sensory structure and this is hereditary.

The fact that not only our physical but also our mental and temperamental characteristics have a hereditary basis has certain important social bearings. It leads us to regard more charitably the limitations of our fellow men. The false doctrines of human equality at birth and of freedom of the will have determined a line of practice in the fields of education and criminology that, it seems to me, is not productive of the best results. In education we must know the child's native capacities before we can

properly train. In dealing with delinquents we must know the hereditary, mental and emotional make-up before we can get an explanation of the bad conduct and before we can intelligently treat the delinquent. Organized society is too prone to "pass the buck" of its own shortcomings to the hypothetical "bad-will" of the offender against the mores. We should do better if we treated the misdemeanant as we treat a puppy whose actions displease us. Either train him carefully, if he is trainable; otherwise, put him in a position where the exercise of his instincts will not offend us.

The relation of the glands of internal secretion, commonly known as endocrine glands, to human development and human behavior is becoming daily more obvious. Stature, build, proportions; details of development of bone, teeth, nails, hair, skin; intelligence, emotional control, all these things can be shown to be influenced by endocrine secretions. Indeed, it seems naturally to follow that the hereditary differences between people are due to hereditary differences in the activity of these glands. Now these glands, as is well known, secrete substances called "hormones" which regulate our physical, mental and temperamental constitution. The special quality and quantity of these hormones is determined by the idiosyncrasies of the enzymes of the germ cells. The hormones that determine our personality, constitute the bridge that connects this *personality* on the one hand, with the *specific enzymes* packed away in the chromosomes of the germ cells, on the other. You and I differ by virtue of the difference of atomic structure and atomic activity of the enzymes and hormones which make up that part of the stream of life-yeast which has got into and is activating our protoplasm and will activate that of the fertilized egg that results from us and our consorts. Thus each is what he is in his physique, in his thoughts and in his reactions largely by virtue of the peculiar properties of those extraordinary activating substances, which are specific for him and other members of his family and race or biotype. The future of human genetics lies largely in a study of these activities, and the origin of differences or mutations in them.

The study of human genetics leads into numerous fields of the physiology of human reproduction. Of these one of the most significant is that of twin-production. This topic has many aspects. As is well known twins are of two types. Two-egg twins come from two eggs simultaneously ovulated and one-egg twins arise by a division into two embryos of a single young embryo. The two children which thus arise from one egg are often so marvellously similar that they are called "identical twins." Now these identical twins give a measure of the relative importance of heredity and environment, as Francis Galton pointed out. It is, indeed, marvellous to

see how such twins, even though living far apart, retain their initial resemblance, experience at almost exactly the same time similar disease and emotional disturbances. Even the thoughts, as measured by the so-called "association" tests and the finger prints are marvellously similar. The dissimilarity of environment has had little effect on altering the rhythm of development, which is controlled by an internal mechanism. The two-egg twins are merely ordinary brothers and sisters who are born simultaneously, and though the intrauterine environment and that of early years is as nearly identical as possible, yet they are as dissimilar as brothers and sisters are apt to be.

Though human heredity is the leading branch of eugenical research, yet it is only one. A fascinating branch of the subject is that of mate selection, including a study of those external and internal conditions that control in this phenomenon. While propinquity is often considered the all-sufficient basis of mate selection, yet statistical research reveals such facts as these; that there is a selection of mates of corresponding divergence from the mean in stature; that red-haired persons do not marry as frequently as expected on a random basis; that persons of opposite temperaments tend to marry with each other.

Research on fecundity, especially the differing fecundity of peoples having dissimilar social values in the population has not received the attention it deserves; still we know something of the fractions of sons and daughters of college men and women and have some facts available towards a study of fecundity of the socially inadequate. Always, however, it is not to be forgotten that it is the residuum of surviving children of a marriage that counts in the race and the children of the less socially adequate strains, are permitted a larger selective death rate than are those of the more efficient strains. That is one reason why from the less developed strains, vigorous and effective progeny are occasionally arising; while some lines of the more effective and prosperous families end in weak and lethal descendants. Modern surgery has done much to keep alive weak and defective individuals, but little to improve racial qualities. Selection and its effects, including those of war, have been all too little studied.

But fecundity of stocks is only a part of the problem in a country which like ours, has in a single year, added about as much to the population by immigration as by birth. Probably never before in the world has such a migration of all sorts of races in such numbers, over so great a distance, taken place. Here in America we have watched the process with misgivings, and felt a lack of sufficient knowledge to direct our action. The present policy of *selecting* immigrants is a reasonable one, certainly; and

every one who recognizes the effect of quality of the germ plasm on national life, hopes it will be continued and extended until we know something of the family, as well as individual performance, of each applicant for entry into the United States. The best, as well as the most recent study of the effect of a mixture of races upon a country is Mr. Charles W. Gould's "America: A Family Matter," and his conclusions are not encouraging. But the student of human genetics hopes to put this marvellous mixture of races to account in his study of human inheritance. The greatest opportunity in the world is offered for the study, since nearly all the races of mankind can be found in New York City alone, in considerable numbers, talking the one language and making mixed marriages, which are often strikingly diverse. This is a field that is extremely alluring and which has been little worked.

But I fear I tire you with this prolonged discussion of the results and the future of eugenical research. No doubt there are many who are inquiring, "But where does environment come in?" And there are others who would urge that the great problem for investigation is that of the relative importance of heredity and environment. It seems to me that we should not formulate the problem in this manner. There is no heredity without environment and few environmental effects which are not dependent also upon heredity. Schooling is good for those who are not feeble-minded; moral training yields excellent results in the case of such as have normal inhibitions; musical education is valuable if the elements of musical capacity are present; painting lessons are fine if the pupil be not color blind. Certainly every child deserves the greatest possible opportunities; but the same conditions will be an opportunity to him who is able to take advantage of them, and no opportunity to him whose hereditary limitations do not enable him to use them.

And finally, what are some of the practical applications that we may expect to be made of eugenical research? One, certainly, is a higher estimation of the importance of hereditary capacities in human behavior. This may save us from disregard of innate differences in capacities which lead us on the one hand to adjudge all men equally capable of acting in accordance with the *mores;* and, on the other, to explain all offences as due to poor environment. Both false views neglect the fact of differences in inborn capacities.

Again, there will come a realization of the importance of heredity in marriage matings. Young persons to whom marriage is so serious a matter, will be led to stop and consider, when they feel they are falling in love, and inquire concerning consequences to offspring. Already there is

being developed a well defined conscience in the matters of cousin marriages and of matings into families with grossly defective members. This is shown by the extensive correspondence that the Eugenics Record Office has been obliged to enter into with persons who are contemplating marriage. They are quite willing to submit an extensive account of their family traits; and they write to learn what is known about the inheritance of some family weakness or defect. The people who make these inquiries are often unusually intelligent and not at all radical; some of them stand high in the social world. It is a high idealism and a forward looking one which leads them to seek the desired knowledge and one can only respond to these requests, telling what is known, or highly probable, in respect to the recurrence of the family defects in the offspring. Whether the conclusions that one is able to give are always very valuable or not, at least the custom of considering children and their inheritance of familial traits is one to be encouraged. Normal persons marry to beget normal children and it is natural for them to seek information concerning heredity of particular traits.

And again, it may be hoped that the study of racial characters will lead men to a broader vision of the human race and the fact that its fate is controllable. We may hope that reasonable persons will consider the progress of mankind, not by the years or generations merely, but by centuries or millenia. We may learn by the history of mankind in the last 20,000 years how near it has come to extinction; and we must recognize that it will take only a little interference with natural instincts and a little interference with natural selection during a few generations to bring the species, or one race of it, rather abruptly to an end, just as other human races have come to an end in historical times. The human species must eventually go the way of all species of which we have a paleontological record; already there are clear signs of a wide-spread deterioration in this most complex and unstable of all animal types. A failure to be influenced by the findings of the students of eugenics or a continuance in our present fatuous belief in the potency of money to cure racial evils will hasten the end. But if there be a serious support of research in eugenics and a willingness to be guided by clearly established facts in this field, the end of our species may long be postponed and the race may be brought to higher levels of racial health, happiness and effectiveness.

GENETIQUE ET ADAPTATION

L. CUÉNOT

University of Nancy, Nancy, France

Les recherches génétiques modernes, parmi lesquelles les travaux américains tiennent une place prépondérante, nous ont appris que le potentiel ou patrimoine héréditaire, substratum matériel de ce qui passe des parents aux descendants, est constitué d'une part par le cytoplasme compliqué de l'oeuf, d'autre part par les substances nucléaires mâle et femelle. La polarité, la symétrie, le type de segmentation et le plan ou la position et la proportion relatives des organes futurs sont déterminés uniquement par le cytoplasme de l'oeuf, dans lequel il y a fréquemment des substances organo-formatrices visibles ou *morphoplasmes*, mais les différenciations des stades ultérieurs du développement, c'est à dire les caractères spécifiques et individuels, sont influencés à pouvoir égal par l'oeuf et le spermatozoide, donc par les substances nucléaires qui constituent l'appareil chromosomien. L'analyse mendélienne révèle dans celles-ci l'existence de facteurs indépendants, que l'on peut regarder comme de très petites masses matérielles de substances chimiques définies, susceptibles de changements ou *mutations* qui conditionneront un changement somatique dans une génération suivante, le changement somatique pouvant être extrêmement minime ou au contraire constituer d'un coup un écart considérable du type normal. Par extension du terme, comme nous ne nous apercevons de la mutation chromosomique que par l'effet qu'elle produit sur le soma, nous pouvons appeler aussi mutation la variation héritable. On ne sait pas provoquer expérimentalement des mutation déterminées; elles apparaissent isolément, d'une façon imprévisible; cependant il est permis de croire qu'elles sont en relation lointaine avec des changements du milieu extérieur (excessive variabilité des animaux domestiques comparée à l'uniformité de leurs souches sauvages, mutations innombrables des Achatinelles des îles Sandwich qui n'ont dû recevoir cependant à l'origine que très peu d'exemplaires, etc.). On comprend qu' une modification du chimisme général puisse être produite par un changement de climat, par l'introduction dans la nourriture d'une substance nouvelle, et que cette modification retentisse sur les cellules du corps, y compris les sexuelles; ces dernières présenteront, à échéance plus ou moins éloignée,

des mutations visibles, qui pourront être la dernière étape de petits changements invisibles, cumulatifs. Les faits semblent montrer, contrairement à ce que croyait Delage, que les individus d'une même espèce different assez les uns des autres (bien que nous ayons une tendance à les croire identiques) pour que la modification possible les touche très inégalement, et qu'il n'y ait qu'un nombre restreint d'entre eux qui présentent des mutations.

La mutation peut se produire aussi bein dans des cellules sexuelles que dans des cellules somatiques initiales de bourgeons quelconques (mutations gemmaires); les graines portées par des plantes issues de mutations gemmaires peuvent reproduire par voie sexuée le type nouveau, qui peut être également propagé par bouturage (Pomme de terre).

On ne voit pas qu'on puisse faire d'objections graves à ces conceptions factorielles ou mendéliennes et à celle de la mutation, étayées, semble-t-il, sur des preuves sans nombre. Partant de cette base, on peut se demander quelle est la position des mendéliens ou mutationistes à l'égard des grands problèmes de l'hérédité des caractères acquis, de l'origine des adaptations et des orthogénèses? Je laisserai de côté le troisième problème, dont la solution dépend beaucoup, du reste, de celles données aux deux premiers.

Le *caractère acquis* est une modification apparaissant chez un individu, plante ou animal, à un âge quelconque, qui est visiblement l'effet d'une cause extérieure et accidentelle, à tel point que si cette cause n'était pas intervenue, la modification ne se serait assurément pas produite. Il est bien entendu que le caractère acquis est la différence entre l'état normal ou l'état qui a servi de point de départ, avant l'action de la cause modifiante, et l'état nouveau, après action de cette cause. Pour qu'un caractère soit considéré comme acquis, il faut que la relation de cause à effet apparaisse avec évidence, soit qu'on ait fait agir la cause expérimentalement, soit que l'observation naturelle ait, ce qui est rare, la rigueur et la certitude d'une expérience. Il est inutile d'insister sur l'importance capital du phénomène pour l'explication générale de l'évolution et en particulier des adaptations; en effet, comme on pouvait—s'y attendre, les réactions de l'individu à une action extérieure quelconque ont très généralement une value adaptative ou protectrice: une peau blanche qui se pigmente au soleil protége efficacement contre l'action nocive des ultra-violets, l'immunité garantit contre une nouvelle atteinte de la maladie qui la déterminée; un muscle, une articulation, exercés dans de certaines limites, fonctionnent plus efficacement et plus aisément qu'avant l'entraînement; un acte appris dont on a l'habitude passe presque à l'état de réflexe ou d'instinct. Si l'hérédité des caractères acquis existe, si faible soit-elle nous

possédons la clef d'une quantité énorme d'adaptations; si elle n'existe pas, il faut trouver d'autres explications très différentes. Ce n'est pas seulement une question qui intéresse des savants spéculatifs, renfermés dans leur tour d'ivoire; c'est aussi une question d'ordre social. Quand on dit au grand public que la pratique des sports, même excessifs, prépare des générations nouvelles vigoureuses, on a certainement l'idée que les "athlètes complets" ou même différenciés par des exercices extraordinaires légueront à leurs descendants au moins un rudiment de leurs qualités acquises. C'est certainement l'opinion des éleveurs qui pensent que les effets de l'entraînement des Chevaux de course, de la bonne ou mauvaise nutrition du bétail, sont transmissibles dans une certaine mesure.

Il y a des catégories distinctes de caractères acquis relevant de causes différentes: 1. les mutilations; 2. les effets des maladies parasitaires produisant une intoxication générale; 3. l'action des grands facteurs naturels, lumière, température, humidité, salure, nouriture; 4. les effets de l'usage et ceux du non-usage; 5. les acquisitions du dressage, de l'éducation intellectuelle ou sportive. Il faut reconnaître que la démonstration négative, c'est à dire celle de la nonhérédité des caractères acquis de l'une des catégories, vaut pour celle-là seulement, et ne saurait légitimement être étendue aux autres: ce sont des problèmes distincts. Mais, par contre, s'il y avait une expérience qui montrait indiscutablement l'hérédité d'un caractère vraiment acquis, ce serait une probabilité bien forte pour d'autres catégories, car bien que l'on ne comprenne absolument pas comment une modification corporelle acquise pourrait s'inscrire sous sa forme plus ou moins atténuée dans le patrimoine héréditaire, si le fait était prouvé une fois, l'argument de l'incompréhension perdrait toute sa valeur.

Pour la 1re catégorie de caractères acquis, on peut dire que la réponse est définitive; depuis les critiques et les expériences de Weismann, maintes fois répétées, personne ne croit plus à l'hérédité des mutilations; les observations de tous les jours confirment celles des biologistes, et il est certain que les pseudo-exemples de transmission de mutilations que l'on rapporte assez souvent chez des animaux domestiques et de famille humaine sont ou de simple coincidences ou des erreurs d'observation. Les expériences de Brown-Séquard, du reste mal faites, qui concernent l'hérédité de mutilations et celle de désordres physiologiques consécutifs à des mutilations nerveuses, ont été complètement controuvées par des travaux dans lesquels on peut avoir confiance (Wrzosek et Macïesza) et il n'en reste rien.

Divers auteurs ont affirmé l'hérédité des acquisitions de la 5m catégorie, notamment du dressage, quelque peu vraisemblable que cela paraisse;

en particulier, Hachet-Souplet[1] (1912), rapporte les exemples suivants qu'il considère comme démonstratifs: un Singe macague auquel il avait appris, non sans peine, à tuer des Rats, donna naissance à des petits qui chassaient merveilleusement les Rats; des Chats habitués à respecter les Souris ont eu des petits qui ne prenaient pas de Souris, même quand on retardait intentionellement la distribution de leur nourriture; des Passereaux habitués à tirer la chaîne d'un petit puits pendant six générations ont donné naissance à des jeunes qui, sans dressage, savaient tirer la même chaîne. Une chienne avait été dressée à faire des pirouettes rapides à gauche; une fille de cette chienne, élevée à la campagne, n'ayant aucun exemple sous les yeux et n'ayant reçu aucun dressage, se mit à faire toute seule des pirouettes à gauche vers cinq ou six mois. Tout cela est bien étonnant, et il est permis de rester sceptique; bien que l'on ne puisse critiquer des expériences que l'on n'a pas suivies, je suis persuadé qu'il y a un "trou" dans ces observations, dû peut-être à la supercherie des aides et à des dressages subreptices demeurés inaperçus, et je ne doute pas que l'hérédité des habitudes aille rejoindre celle des mutilations. C'est dire que nous ne croyons nullement que les instincts sont des habitudes acquises, devenues héréditaires.

La 3^{me} catégorie concerne les facteurs de milieu; personne ne doute que les facteurs de milieu ont une influence déterminante extraordinaire sur les caractères des animaux et des plantes, et que, lorsqu'on les change expérimentalement jusqu'aux limites extrêmes compatibles avec la vie, il en résulte souvent des modifications notables chez les individus soumis dès modifications notables chez les individus soumis dès le jeune âge au changement d'ambiance. Mais la question est de savoir si ces modifications passent, même à un degré très diminué, à la génération suivante élevée en milieu normal; si oui, nous comprenons facilement la formation des races ou sous-espèces géographiques; en effet, les résultats de l'action de milieu seraient necéssairement cumulatifs, et après un nombre suffisant de générations passées dans le milieu modifiant, l'espèce pourrait être très notablement transformée, le plus souvent dans un sens utile (car, sans cela, elle ne résisterait pas au changement), et, même en revenant au milieu normal, l'espèce nouvelle pourrait conserver ses caractères acquis. Si non, les effets de l'action de milieu se produisent à nouveau pour chaque individu, il n'y a pas de modifications cumulatives, et l'influence de l'ambiance sur le corps n'a aucun intérêt au point de vue de l'évolution.

On a fait beaucoup d'expériences sur les facteurs de milieu, surtout avec des Insectes: des centaines d'essais ont donné des résultats négatifs au point

[1] Hachet-Souplet, La genèse des instincts, étude expérimentale (Biblioth. de Philos. scient., Flammarion, Paris, 1912). Voir p. 239.

de vue de la transmission du caractère acquis; quelques-uns seulement (Standfuss, E. Fischer, Schröder) ont eu un résultat faiblement positif, mais ils sont insuffisamment probants, les auteurs ayant opéré avec des espèces naturellement si variables qu'on est en droit de se demander si le caractère de coloration qu'ils ont cru acquis n'existait pas avant l'expérience chez certains individus. Les expériences de Kammerer sont plus embarrassantes encore: il a publié de 1904 à 1911 un grand nombre de travaux démontrant la considérable influence de l'ambiance sur les modes de reproduction des Amphibiens (*Alytes obstetricans*, *Salamandra maculosa* et *atra*), sur la couleur d'Amphibiens (*Salamandra maculosa*) et de Reptiles (*Lacerta*), et mettant en évidence dans la plupart des cas la transmission héréditaire des caractères acquis. Ce n'est pas trop dire qu'à première vue les résultats de Kammerer paraissent incroyables; il disposait, il est vrai, d'une installation exceptionnelle, au Prater, à Vienne (Biologische Versuchsanstalt de l'Académie des Sciences), mais qu'il ait pu réaliser, même avec cette installation, des élevages d'une difficulté aussi grande et d'aussi longue durée, est déjà surprenant; dès le premier jour, les expériences de Kammerer ont paru trop bien réussies, trop démonstratives et trop extraordinaires pour ne pas cacher des erreurs. Boulenger et Bateson les ont critiquées sévèrement; on a parlé même de tricheries et de substitution de préparations; Hans Przibram, qui dirige la station du Prater, a bien voulu me dire qu'il n'en était rien, mais c'est au moins une indication que les résultats de Kammerer ont rencontré généralement l'incrédulité. Si Przibram ne les avait pas patronnés, pour ainsi dire, en rendant compte des travaux de Kammerer dans son excellent livre *Experimental-Zoologie* (tome 3, 1910), j'imagine qu'on aurait attendu, pour en tirer argument, qu'ils aient été confirmés par un ou deux observateurs d'autres pays, ce qui n'a pas encore eu lieu, tout au contraire.

En somme, jusqu'ici l'expérience décisive, vérifiée certaine manquait encore, et les biologistes avaient le droit de ne pas croire à l'hérédité des caractères acquis de la 3me catégorie (facteurs de milieu) et de la 2me (immunité), mais le problème restait toujours posé; cela est si vrai, que la croyance à l'hérédité de ces caractères acquis était presque une affaire de foi, de nationalité; la grande majorité des zoologistes français tenait pour l'affirmative, à la fuite de Giard, d'Edmond Perrier, de Le Dantec, de F. Houssay, de Delage, tous plus ou moins lamarckistes, les Américains, sauf quelques paléontologistes, penchaient plutôt pour la négative. Mais la question a pris récemment une face nouvelle avec les expériences de M. F. Guyer et E. A. Smith (1920).[2]

[2] Guyer et Smith, Studies on cytolysins. 11. Transmission of induced eye-defect (Journ. of exp. Zool., 31, 1920, p. 171).

En injectant à des Poules des cristallins broyés de Lapins, ils obtiennent un sérum cristallolytique; celui-ci est injecté à des Lapines albinos pleines depuis 10 à 13 jours (époque particulièrement importante pour le développement du cristallin); la cristallolysine de la Poule n'agit pas sur les cristallins des Lapines adultes, peut-être parce qu'elle n'atteint pas ces organes, alors dépourvus de vaisseaux, mais elle passe à travers les placentas, et affecte plus ou moins fortement les foetus infermés dans l'utérus; beaucoup meurent; ceux qui survivent présentent parfois (9 cas sur 61 petits) un cristallin plus petit et plus ou moins opaque, ou bien de la microphtalmie ou même une fonte complète de l'oeil. Sans aucun doute, cela est bien dû à l'action spècifique de la cristallolysine, car les Lapins de contrôle (48), provenant de mères injectées soit avec du sérum de Poules normales, soit avec du sérum de Poules préparées avec un tissu de Lapin autre que le cristallin, n'ont présenté aucune modification de l'appareil visuel. Ce n'est pas non plus une coincidence fortuite due à une mutation passée inaperçue, car on ne connaît dans aucune race de Lapins d'animaux à yeux naturallement défectueux. Jusqu'ici il n'y a rien d'absolument nouveau ni de surprenant, car on savait déjà que des sérums cytotoxiques ou des anticorps immunisants peuvent passer à travers les placentas pour aller impressionner des organes de foetus. Bien entendu, les yeux défectueux des jeunes constituent un caractère acquis certain, car si l'on n'avait pas injecté à leurs mères de sérum cristallolytique, les yeux seraient restés sains.

Or, *ce caractère acquis s'est montré héréditaire*; il a été transmis jusqu'à la 8^me^ génération sans autre traitement que les injections originelles; l'anomalie tend à devenir plus grave dans les générations successives et aussi à apparaître dans un nombre plus grand de jeunes; la transmission est souvent d'un type irrégulier, tantôt l'oeil droit seulement ou le gauche, tantôt les deux yeux étant atteints; mais dans les dernières générations, sans doute parce que les parents sont pris de préférence parmi les individus les plus touchés, il y a un nombre croissant de jeunes qui ont les deux yeux affectés. Pour démontrer que le réapparition de la dystrophie spécifique est bien due à l'hérédité et non à un passage d'anticorps une fois fabriqués, Guyer et Smith ont croisé des mâles défectueux avec des femelles normales (sans relation familiale avec les stocks traités): la 1^re^ génération a des yeux constamment normaux (dominance du caractère yeux normaux), mais les femelles hétérozygotes de cette génération, croisées à nouveau avec des mâles défectueux, ont donné un certain nombre de petits à yeux dégénérés. Au point de vue génétique, cela ne peut se comprendre que si l'on admet que le patrimoine héréditaire des mâles a subi une modification spécifique.

Bien entendu, on ne pourra faire fond sur l'expérience de Guyer et Smith que le jour où elle aura été refaite, avec les mêmes résultats, par d'autres observateurs; mais il semble bien que les deux auteurs ont opéré avec soin, et ont prévu et évité les causes d'erreur et les critiques possibles. Si l'expérience de Guyer et Smith est bonne et valable, que de conséquences graves et que changements dans nos manières de voir!

Puisque des anticorps spécifiques peuvent produire des modifications spécifiques dans les cellules germinales, nous ne pouvons pas échapper à cette conséquence qu'il y a dans le patrimoine héréditaire une substance ou une particule qui a une certaine correspondance avec le cristallin développé, puisque la cristallolysine (qu'elle soit substance ou propriété, peu importe) touche d'une part les cristallins en voie de formation du foetus, et d'autre part les cellules germinales de celui-ci, de telle sorte que ces dernières seront l'origine de petits à cristallin défectueux. On comprendrait à la rigueur que la cristallolysine, à la façon d'un poison, modifie quelque peu la cellule germinale, mais d'une façon quelconque, de manière à ce qu'elle donne naissance à un petit plus ou moins dystrophié; mais que la modification soit spécifique, voilà qui est stupéfiant! Il y a donc dans le germe une partie qui est "*représentative*" du cristallin, par exemple un colloide déterminé analogue aux colloides du cristallin développé. Et s'il y en a pour le cristallin, il doit y en avoir pour toutes les cellules différenciées de l'organisme, les pigmentaires, les nerveuses, les adipeures, les stomacales, les rénales, etc. Nous revenons ainsi à une théorie particulaire de la constitution des cellules germinales, à des *déterminants chimiques*, théorie que Delage[3] a autrefois formulée d'une façon très nette (1895), en reprenant et modifiant des idées plus ou moins analogues de Weismann et de W. Roux. *Le germe serait un microcosme renfermant tous les colloides différents de l'organisme adulte;* si l'expérience de Guyer et Smith est vraie, je ne vois pas qu'on puisse échapper à cette conséquence. Elle n'a du reste rien de contradictoire avec la conception mendélienne, car le déterminant chimique ou colloide représentatif paraît bien se confondre avec le facteur mendélien. En effet, Guyer et Smith montrent que l'élément germinal touché par la cristallolysine se comporte à peu près comme un facteur mendélien recessif: quand des mâles ou des femelles à yeux anormaux sont croisés avec des individus non traités, provenant pour plus de sûreté d'autres régions, toujours la progéniture apparaît avec des yeux normaux; mais les petits sont des hétérozygotes et renferment à l'état dominé le caractère yeux défectueux; en effet, si ces Lapins d'apparence normale sont croisés avec d'autres à

[3] Delage, La structure du protoplasma et les théories sur l'hérédité, etc. Reinwald, Paris, 1895 (voir p. 807).

yeux défectueux, il apparaît cette fois dans leur descendance un nombre plus ou moins grand de petits à yeux anormaux. Deux individus à yeux défectueux (homozygotes dominés), croisés ensemble, devraient, dans l'hypothèse de facteurs mendéliens simples et typiques, donner uniquement des petits présentant l'anomalie; il n'en est pas toujours aussi, mais il y a une majorité frappante de cristallins opaques ou petits dans leur descendance. Les documents sont encore insuffisants pour voir clair dans la génétique du caractère, mais en gros, abstraction faite de détails qui s'éclairceront probablement plus tard, les caractères yeux normaux et yeux lysès forment en couple allélomorphique, avec dominance du premier.

Est-ce à dire que l'expérience de Guyer et Smith, même si elle était confirmée dans tous ses détails est parfaitement satisfaisante? Il s'en faut de beaucoup; un mauvais sort veut que les preuves de l'hérédité des caractères acquis ne présentent jamais cette plénitude d'évidence qui entraîne irresistiblement la conviction et laisse l'esprit en repos. La cristallolysine a une action vraiment déconcertante: elle n'agit pas sur les cristallins de la mère gestante, première anomalie qui, il est vrai, a reçu une explication plus ou moins bonne; elle agit capricieusement sur les cristallins en voie de développement des foetus (9 fois sur 61) et d'après l'hypothèse, sur les déterminants cristalliniens des cellules germinales de ces mêmes foetus. On doit donc s'attendre à ce qu'elle touche également les cellules germinales dans les ovaires de la mère gestante, aussi bien que celles des foetus; or, il n'en est rien: les Lapines qui survivent aux injections de sérum anticristallin et qui ont donné des jeunes à yeux anormaux, sont couvertes à plusieurs reprises par les mêmes mâles normaux, *après que les traitements sériques ont été arretés* (depuis combien de temps?), et pas une trace de malformation oculaire n'est visible dans leur descendance, cependant nombreuse. Il y a là quelque chose de tout à fait incompréhensible, à moins d'admettre que les cellules germinales ne peuvent être modifiées qu'à des stades particuliers, celui de la période de multiplication des gonies, ou bien celui de la synapse. Or, on sait que chez les femelles de Mammifères, ces phénomènes se passent chez l'embryon, et que l'adulte n'a plus que des ovocytes qui s'accroissent lentement et inégalement pour arriver successivement à maturité. Nous avons un moyen de vérifier cette hypothèse subsidiaire, car les mâles adultes présentent toutes les phases de la spermatozoide; an injectant du sérum anticristallin à des mâles, on devrait toucher leurs cellules sexuelles à la période sensible; et accouplés plus tard à des femelles normales, ils devraient transmettre l'anomalie, qui ne serait visible que chez leurs petits-enfants. C'est une expérience cruciale à faire; je ne vois pas que Guyer et Smith l'aient tentée. Il sera indiqué, pour

simplifier l'expérience, de ne pas utilisé seulement la Poule comme source de cristallotoxine, mais bon le Lapin lui-même, pour ne pas introduire le facteur étranger sérum de Poule. Du reste Guyer[4] a réussi récemment (1921) à obtenir un jeune Lapin à deux yeux défectueux en injectant à plusieurs reprises à sa mère normale des cristallins broyès de Lapins, avant qu'elle fut pleine et pendant sa gestation. Un Lapin peut donc fabriquer un anticristallin—Lapin aussi efficace que celui engendré par une espèce étrangère.

Revenons aux caractères acquis: les expériences de Guyer et Smith, en les supposant confirmées dans le fait et dans l'interprétation, permettent désormais d'accepter l'hérédité des caractères acquis sous l'influence des grands facteurs généraux du milieu; en même temps que ceux-ci produisent leur effet plus ou moins adaptatif sur certains tissus du corps, ils modifient d'une façon parallèle les colloides représentatifs des cellules germinales, de telle sorte qu'il pourra y avoir effet cumulatif du même facteur général agissant sur des générations successives. C'est exactement ce qui a été supposé depuis longtemps par Weismann luimême, et ce que l'on a désigné sous le nom d'*induction parallèle* (mot de Detto). Weismann a illustré le fait par l'exemple célèbre du *Chrysophanus phlaeas*: ce Papillon, à très large répartition géographique, varie comme beaucoup d'autres suivant les saisons et les localités: dans la région septentrionale, l'aile supérieure est rouge doré avec bordure noire et points noirs sur le disque, l'aile inférieure noirâtre avec une bande submarginale rougeâtre; dans l'Europe méridionale, on trouve dans la génération d'été des exemplaires plus grands, dont les deux ailes sont presque entièrement noires (forme *eleus*), avec tous les intermédiaires entre cette forme et le type. Si l'on élève en Allemagne des chenilles provenant de *phlaeas* de Naples et qu'on soumette les pupes à une basse température (10°), il se développe des Papillons un peu moins noirs que ceux qui volent à Naples, mais beaucoup plus que les allemands; au contraire, des pupes d'origine allemande soumises à une température élevée (38°) donnent des Papillons qui sont un peu moins rouge feu et un peu plus noirs que les Papillons allemands habituels. Le caractère géographique et héréditaire des races méridionales est donc dirigé dans le même sens que l'action d'une température élevée sur les pupes; et il paraît vraisemblable de supposen que lorsque l'espèce, primitivement septentrionale, a gagné les régions du midi, l'élévation de température, agissant pendant de nombreuses générations, a affecté avec un résultat parallèle les éléments formateurs de couleur des ailes et les colloides représentatifs du pigment dans les cellules germinales.

[4] Guyer, Immune sera and certain biological problems (Amer. Natur., 55, 1921, p. 97).

Jusqu'ici on pensait que l'immunité, caractère acquis apparu après une maladie microbienne, n'était pas transmissible, si ce n'est à une première génération par échange placentaire; or Guyer (1921) rapporte que des Lapins injectés successivement avec le vaccin typhique et des germes typhiques vivants peuvent transmettre à leurs jeunes et *même à la génération suivante* la propriété d'agglutiner des bacilles typhiques dans du sérum dilué. Si cette expérience, en contradiction avec les travaux antérieurs, est confirmée, on pourra comprendre pourquoi les habitants d'une contrée où sévit une maladie habituelle sont en général plus aptes à y résister que ceux d'une contrée indemne, la maladie étant moins sévère dans le premier milieu, ou bien le nombre des individus absolument immune y étant plus considérable. Il y aurait, en même temps qu'une sélection des plus résistants, transmission d'une immunité partielle.

Reste la catégorie la plus importante, les caractères acquis par l'usage [5] et le non-usage, question qui creuse le fossé profond entre les lamarckistes et les opposants. La question n'est pas abordable expérimentalement; aucune expérience, même prolongée pendant plusieurs générations humaines, ne montre ni ne peut montrer l'hérédité des effets de l'adaptation fonctionnelle individuelle; aussi les lamarckistes ont-ils cherché la démonstration dans des observations naturelles; on connaît en effet un certain nombre de caractéres héréditaires, apparaissant déjà chez les embryons en dehors de toute cause extérieure, qui semblent résulter de la fixation de réactions individuelles à la pression, à l'exercice ou au défaut d'usage; ce ne peut être qu'un argument de vraisemblance, mais une accumulation d'exemples de cette sorte pourrait toutefois avois une valeur démonstrative, bien que l'on ne comprenne absolument pas comment un effet mécanique, produit chez l'animal développé, pourrait s'inscrire dans le patrimoine héréditaire. Les meilleurs exemples lamarckistes sont: 1^e la ressemblance des courbures du corps d'un Poisson bon nageur avec celles d'un modèle plastique soumis aux mêmes courants d'eau qu'un Poisson en nage filée (F. Houssay); 2^e la perforation de la paroi operculaire des têtards de *Bombinator*, même en l'absence des pattes antérieures qui provoquent normalement cette perforation (Braus); 3^e l'échancrure de la lèvre supérieure du Sanglier mâle, en rapport avec la canine relevée en dehors; 4^e les callosités des surfaces plantaires des animaux marcheurs (Semon); 5^e les callosités des surfaces (autres que les plantaires), sur lesquelles s'appuient divers animaux, comme les Chameaux, la Girafe, le Phacochère, les Autruches (Leche, Duerden, etc.); 6^e l'atrophie des yeux chez les animaux cavernicoles ou abyssaux.

[5] Par le mot usage, on entend non-seulement l'usage proprement dit, mais aussi tous les effets mécaniques de traction, pression, etc.

Je n'ai pas l'intention de critiquer en détail ces observations, dont beaucoup mériteraient d'être reprises et étudiées très en détail; je me bornerai à quelques remarques. Un *Sus scrofa* mâle adulte présente comme on sait des canines supérieures fortement relevées, qui retroussent la lèvre; on a évidemment l'impression que c'est la pression exercée par la dent, objet dur, sur les parties molles, qui conditionne cet état; or, si on examine un embryon mâle, avant la poussée des canines, n constate (fig. 1) que la lèvre supérieure présente déjà une échancrure manifeste, à l'endroit où la dent passera bien plus tard. Mais on peut formuler une toute autre hypothèse que celle de l'hérédité d'un caractère mécaniquement acquis; il est évident qu'il

FIG. 1. Tête de foetus de Sanglier (Sus scrofa L.) montrant en *X* le pli préformé de la lèvre supérieure. Gr. nat.

y a chez le mâle une cause interne, dispositif osseux ou autre, qui contramit la canine à pousser en dehors et en haut, au lieu de croître vers le bas: or, n'est-ce pas ce dispositif qui, déjà chez l'embryon, tira sur la lèvre supérieure et y détermine la petite échancrure?

Les callosités des surfaces d'appui, l'exemple de beaucoup le plus favorable aux lamarckistes, sont evidemment déterminées chez l'embryon par une cause actuelle, probablement la pression de surfaces osseuses sur la région épidermique; si l'animal développé s'appuie sur ces callosités, comme l'Autruche étudiée par Duerden, est-ce leur présence, antérieure à l'usage, qui a permis à l'animal d'adopter son attitude spéciale, ou bien l'animal a-t-il pris l'attitude avant d'avoir des callosités? L'un n'est pas plus certain que l'autre.

Quant aux atrophies oculaires des animaux vivant dans l'obscurité absolue, il n'est pas impossible, en se basant sur les résultats de Guyer et Smith, de comprendre leur genèse; des organes tels que les yeux, qui cessent complétement de fonctionner, pourraient produire des modifications humorales spécifiques, des sortes de lysines qui affecteraient les colloides représentatifs dans les cellules germinales, et améneraient graduellement la régression héréditaire.

En résumé, il me semble que les mendéliens qui, jusqu'ici niaient complètement l'hérédité de tous les caractères acquis, même sous la forme de l'induction parallèle, ne peuvent plus se montrer aussi affirmatifs; il est absolument necéssaire de vérifier ou d'infirmer les expériences de Guyer et Smith, en les recommençant avec plus de rigueur, pour mettre enfin un terme à la question irritante de l'hérédité des acquisitions somatiques et nous fixer sur la constitution intime du patrimoine héréditaire.

Il n'y a pas de mot plus fréquemment employé en Biologie que celui d'*adaptation*, non sans quelque confusion dans l'emploi de ce terme. Tantôt on entend par adaptation le fait de l'accommodation d'un individu à des conditions de vie nouvelles pour lui, c'est à dire les modification somatiques plus ou moins favorables, adaptatives comme l'on dit, qui résultent de l'action de ces nouvelles conditions; c'est la régulation ou l'adaptation fonctionnelle.

Tantôt on appelle adaptation l'accord général des caractéristiques d'une espèce et des conditions physiques et biologiques du milieu oú elle vit et oú elle persiste. Il est évident qu'un animal est toujours adapté aux conditions de son milieu: il a un appareil digestif approprié à la nourriture qu'il peut se procurer, un système locomoteur convenable, une fécondité capable d'égaler au moins le taux de destruction normal par carnassiers et parasites, des réactions à la lumière, à la chaleur, etc., qui sont d'accord avec sa structure et ses besoins. L'adaptation d'une forme à son milieu, phénomène global qui ne se constate qu'après coup, est par définition *nécessaire* et *suffisante*, quels qu'en soient les details. Le jour où par suite d'un changement du milieu physique ou de l'arrivée de nouveaux concurrents et parasites, l'espèce n'a plus dans l'ensemble un total qui est en sa faveur, elle émigre si elle peut le faire, ou bien elle s'amoindrit et disparaît, quelle qu'ait pu être dans le passé la perfection de ses caractéristiques, tels les Ammonites, les Ichthyosaures, les gigantesques Dinosauriens, etc. La sélection naturelle est la balance qui pèse la somme des caractéres des espèces et des individus, et qui élimine ceux qui sont trouvés trop légers.

Cette adaptation générale est découpée quelque peu artificiellement en adaptations spéciales, en rapport avec des conditions determinées du milieu: par exemple, on dit couramment que la palmure des pattes des Vertébrés supérieurs est une adaptation à la vie aquatique, parce qu'on voit bien l'utilité d'une rame pour le nageur, et que la palmure a apparu indépendamment chez beaucoup d'espèces aquatiques de groupes différents; mais si répandue qu'elle soit, cette adaptation spéciale n'a pas un caractère de nécesessité, puisque la Poule d'eau (*Gallinula chloropus*) a les doigts bien séparés, tout en étant excellente nageuse, que le Foulque (*Fulica atra*) n'a qu'une frange digitale, et que le Flamant (*Phoenicopterus roseus*) qui ne nage que rarement, a une palmure complète. Il y a aussi des palmures chez des animaux absolument terrestres, soit arboricoles, comme le Galéopithèque et le Gecko *Ptychozoon*, Malaisie, soit habitant les dunes, comme le Lézard *Palmatogecko Rangei* (S. O. Afrique). Chez une forme qui a changé complètement de mode de vie, il peut très bien persister des caractéristiques qui étaient jadis des adaptations spéciales à un autre milieu, et que l'espèce, dans son nouvel entourage, utilise autrement. L'outil le plus précieux de l'Homme, sa main prenante, est un reste d'une ancienne adaptation à la vie arboricole.

Il est très digne de remarque que Lamarck et Darwin, de même que leurs successeurs immédiats, n'ont nullement cherché à expliquer l'adaptation suffisante: leurs théories portent toutes sur un point très particulier, l'évolution des adaptations spéciales et des régressions, en somme sur les orthogénèses. Pour reprendre les exemples qu'ils ont eux-mêmes choisis, Darwin, étudiant la régression de l'oeil de la Taupe, suppose que la Taupe vit dans une galerie souterraine avant que l'oeil ait diminué; s'occupant du planeur du Sciuroptère, il regarde son ancêtre comme un Ecureuil, donc arboricole. Lamarck, pour la palmure des aquatiques, part d'un Oiseau à doigts séparés, mais déjà nageur; pour l'allongement des pattes et du cou d'un Echassier, il admet un Oiseau de rivage obligé de chercher sa nourriture au fond de l'eau. Pour Houssay, l'un des lamarckistes les plus excessifs de l'école française, le corps du Poisson est le résultat du modelage par l'eau, mais il imagine comme point de départ un animal qui vit dans l'eau et qui nage vite, donc forcément un Poisson. Toutes ces théories prennent donc au début l'animal dans un milieu déterminé, auquel il est évidemment adapté d'une façon suffisante, puisqu'il y vit et y persiste, cette adaptation globale comportant nécessairement des adaptations spéciales. C'est la genèse de l'adaptation générale que nous allons étudier.

Reprenant une opinion dont on trouve déjà une trace dans Buffon, j'admets que l'animal "tient sa destinée des organes avec lesquels il est

né," c'est à dire qu'il ne peut vivre et durer que s'il a eu la chance de rencontrer un milieu adéquat à sa structure et auquel il peut accommoder sa physiologie; ne peuvent peupler un milieu que les espèces ou les individus qui présentent *avant d'y entrer* l'adaptation générale necéssaire et suffisante, qui en un mot y sont *préadaptés.* C'est aussi l'opinion de De Vries "le milieu a seulement choisi les formes aptes parmi la foule et n'a pas de relation quelconque avec leur origine," de Th. Morgan "la forme apparaît indépendamment du milieu; une fois apparue, elle peut se perpétuer dans des conditions convenables," de Davenport "la structure existe d'abord et l'espèce cherche du rencontre le milieu qui répond à sa constitution particulière," et d'autres encore.

L'exemple suivant, que j'ai déjà cité ailleurs,[6] permet de bien comprendre ce qu'est cette préadaptation générale: il existe en Lorraine des mares ou ruisseaux salés, formés par des sources naturelles ayant traversé des dépôts salifères triasiques ou par des déchets de salines; la concentration en sels est très variable d'une station à une autre, et dans une même station suivant la saison, l'eau à peine saumâtre en hiver pouvant devenir sursalée au fort de l'été. Ce milieu est habité par une petite faune riche en individus, mais peu nombreuse en espèces, qui provient évidemment de l'eau douce avoisinante; parmi ces habitants de l'eau salée, je n'en retiendrai qu'un, l'Epinoche (*Gasterosteus aculeatus*), qui s'y trouve en grand nombre et s'y reproduit; ce Poisson y atteint une plus grande taille que dans les ruisseaux d'eau douce voisins, et présente certaines modifications dans le nombre des plaques osseuses qui recouvrent en partie les flancs de l'animal. Cette propriété de vivre continuement dans l'eau salée à salure très variable, cette adaptation générale a-t-elle été acquise par un phénomène lent d'acclimatation et de sélection? Pas du tout. L'Epinoche est douée d'une faculté qui est restée ignorée jusqu'au jour où on l'a mise en évidence d'une façon expérimentale, celle de supporter des changements instantanés de salinité; on peut, en effet, transporter brusquement des Epinoches de l'eau douce dans de l'eau de mer, et vice versa, sans les tuer; il y a assurément quelques individus qui meurent, mais beaucoup survivent indéfinement. Si on faisait la même expèrience avec les autres Poissons d'eau douce, ils mourraient certainement au bout de quelques minutes. Ce qui montre bien que cette *euryhalinité* est un phénomène d'ordre cellulaire, lié à une résistance spéciale des tissus périphériques à l'osmose, c'est que l'Epinoche peut vivre également dans de l'eau glycérinée et dans une solution de sucre à 10 pour 100 (Siedlecki). A l'état normal cette propriété est assurément indifférente pour l'Epinoche qui habite en eau douce; elle est fortuite, sans

[6] L. Cuénot, Théorie de la préadaptation (Scientia, 16, 1914, p. 60).

utilité, est un caractère de hasard; mais elle joue un rôle décisif lorsque l'Epinoche a l'occasion d'occuper des eaux saumâtres et sursalées, et elle prend alors la signification d'une préadaptation.

Il ne manque pas d'exemples analogues: toutes les fois que l'on étudie le peuplement d'une place vide actuelle, c'est à dire d'un milieu habitable qui se crée en un point donné par suite de circonstances cosmiques ou d'interventions humaines (ile volcanique qui surgit des flots, eaux thermales ou salines, galeries de mines profondes, conduites d'eau de ville, plantes exotiques acclimatées), on constate que des êtres vivants ne tardent pas à occuper la place vacante; dans tous les cas, le peuplement est opéré par les animaux ou les plantes du milieu analogue le plus voisin, mais ceux-là *seulement* qui sont capables d'y arriver de par leurs réactions sensorielles, de s'habituer à ses conditions spéciales et de s'y multiplier. En somme il y a *filtrage* de la faune et de la flore avoisinantes; seules passent à travers les mailles du filtre les espèces dont l'adaptation générale, convenable pour le milieu dont elles sortent, est aussi convenable pour celui où elles entrent, bien que ce dernier puisse être très notablement différent du précédent.

Cette seconde adaptation générale peut se découper aussi en adaptations spéciales, répondant aux exigences nouvelles; mais ce qui est le plus intéressant, c'est que celles-ci pouvaient être antérieurement des caractéristiques indifférentes ou d'une utilité mêdiocre, n'ayant pas la valeur de nécessités, ou des adaptations qui jouaient un rôle différent; j'ai cité plus haut l'euryhalinité de l'Epinoche, propriété dont il ne fait assurément pas usage quand il vit en eau douce; en voici un autre exemple, non moins démonstratif: une adaptation fréquente des animaux d'eau douce est l'existence chez ceux-ci de gros oeufs peu nombreux, à développement direct donnant naissance à des petits, capables de mener immédiatement le même genre de vie que leurs parents: on connaît par exemple les gros oeufs des Ecrevisses (*Potamobins*, *Cambarus*, etc.), des Crabes d'eau douce (*Potamon*), des *Paloemon* d'eau douce, du Prosobranche vivipare *Paludina*, etc. Les formes marines, au contraire, on des oeufs petits et nombreux donnant naissance à des larves nageuses qui mènent plus ou moins longtemps la vie pélagique, et doivent nécessairement subir des métamorphoses compliquées avant d'acquérir la forme définitive de l'espèce. On voit facilement la raison d'être de cette adaptation: comme la pénétration des animaux marins dans l'eau douce s'est surtout opérée par les estuaires des grands fleuves, on comprend que des larves nageuses auraient été forcément entrainées au loin par les courants souvent violents des cours d'eau; il est donc très avantageux pour des animaux d'eau douce d'avoir des oeufs à développement direct; l'espèce peut ainsi remonter graduellement les cour-

ants et s'étendre en amont, sans risquer d'être refoulée à chaque génération. Cela est si vrai que les deux habitants d'eau douce qui, par exception, ont des larves pélagiques, la Crevette *Atyaephyra Desmaresti* et le Mollusque *Dreissensia polymorpha*, n'ont étendu que récemment leur aire géographique, et cela grâce à la création des canaux, dont le courant est trop faible pour emporter les larves. Or, on dit souvent que la présence de gros oeufs a été déterminée, *après l'entrée en eau douce*, par une influence spéciale de ce milieu; je ne le pense pas; il est beaucoup plus vraisemblable de supposer que parmi les animaux marins euryhalins qui ont pénétré dans les estuaires, quelques-uns avaient déjà de gros oeufs, et que c'est cette préadaptation qui leur a permis de franchir la barrière et de s'établir définitivement en eau douce; on connait du reste de gros oeufs à développement direct chez des types franchement marins, comme le Homard et le *Nophrops*, tous deux proches parents de l'Ecrevisse, et chez des Littorines vivipares.

Les exemples de préadaptations abondent: des animaux littoraux peuvent avoir des caractères de formes abyssales ou pélagiques, des animaux aquatiques de mer ou d'eau douce présentent des dispositifs propres aux animaux terrestres, de simples lucifuges ont des traits de vrais cavernicoles. On peut poser en régle générale que les caractéristiques ou adaptations spéciales à un milieu donné se retrouvent çà et là, éparses chex les habitants du milieu le plus voisin, à l'état de propriétés latentes ou indifférentes ou dépassant les nécessités. Grâce à ces préadaptations, certaines espèces qui en réunissent un nombre suffisant peuvent quitter leur habitat originel pour passer dans un milieu nouveau, inhabité; elles y vivent à l'abri de toute concurrence, s'y multiplient; y varient, et peuvent devenir la touche de nouveaux groupes différenciés. Spécialement intéressantes sont aujourd' hui les formes qui restent pour ainsi dire à la limite de deux milieux, comme les Tsopodes et Amphipodes littoraux qui ne sont plus marins et pas encore terrestres, beaucoup de Batraciens mi-aquatiques mi-terrestres, les animaux et les plantes d'estuaires à moitié chemin entre l'habitat marin et l'eau douce, les animaux d' entrées de caves qui hésitent entre la lumière et l'obscurité. Il suffira de peu de chose pour que soit réalisée l'adaptation nécessaire et suffisante qui permettra de passer la limite, comme l'ont fait autrefois les Cloportes et certains *Talitrus* et *Orchestia* terrestres, la *Dreissensia*, les Caridines, Palémons et Crabes d'eau douce, les Araignées cavernicoles, etc.

Les aphorismes suivants résument notre façon de comprendre l'adaptation: une adaptation suffisante est nécessairement antérieure à l'installation dans un milieu donné.—Il n'y a donc pas de lieu causal entre l'adaptation suffisante à un milieu et les conditions de ce milieu.—La nécessité

et l'organe créent la fonction.—Ce n'est pas la nourriture qui influence la forme des dents, c'est celle-ci qui détermine le choix de la nourriture (O. Aichel).—Ce n'est pas l'usage de la nourriture cuite qui a amené la reduction du volume de nos dents et des mâchoires, si évidente quand on compare les premiers Hommes à l'Homme civilisé actuel; c'est plutôt cette régression qui nous a imposé l'usage d'une nourriture facile à mâcher.—La Nature n'a point taillé les dents [humaines] pour les diverses utilitiés qu'elles présentent, mais les dents s'étant trouvées, par un arrangement fatal, prendre telle ou telle forme, il en est résulté telle ou telle utilité (Philosophes grecs prédécesseurs d'Aristote).—Ce n'est pas parce que la Girafe broute des arbres qu'elle a un long cou, mais c'est parce qu'il lui est venu un grand cou qu'elle n'a pu faire autrement que de brouter des arbres.—Les animaux cavernicoles entrent dans les cavernes parce qu'ils y trouvent des conditions adéquates à leur structure et physiologie. Ils sont cavernicoles parce que leurs yeux sont dégénérés et parce qu'ils ont perdu leur pigment, avant d'être entrés dans les cavernes (Banta).—Les plumes des Oiseaux, triple adaptation au vol, à la protection du corps contre la déperdition de la chaleur et contre les traumatismes, ont dû apparaitre avant ou pendant la transformation des membres antérieurs en ailes; je crois qu'on trouvera quelque jour un Reptile-Oiseau, antérieur à l'*Archoeopteryx*, ne volant pas et ayant déjà des plumes.—Les habitats des plantes sont déterminés par leurs particularités de structure et non *vice versa* (H. B. Guppy).

Il est à peine utile de faire remarques que la notion des préadaptations est en parfait accord d'une part avec la conception mendélienne ou factorielle, d'autre part avec les idées sur les mutations; celles-ci étant indéterminées au point de vue fonctionnel, sans relation utilitaire avec les conditions de milieus on ne peut comprendre l'adaptation indéniable des êtres à leur amblance qui si elle est le résultat de rencontres heureuses, si l'on vent d'une suite d'essais comportant beaucoup d'erreurs et quelques réussites. Nous ne connaissons que ces dernières, aussi tout ce qui survit est necéssairement adapté au milieu à tous les points de vue, ce qui a donné lieu à l'illusion finaliste de l'école d'Aristote.

Si la doctrine génétique moderne parait bien assise sur le trépied du mendélisme, de la mutation et de la préadaptation, la vérité oblige à ajouter des ombres au tableau; je veux parler d'appareils dont le fini d'éxécution mis en regard de leur faible utilité apparente est difficilement explicable dans l'une quelconque des théories de l'adaptation: ce sont les *coaptations,* ou ajustements réciproques de parties indépendantes, d'une curieuse perfection mécanique, dont les Arthropodes, entre autres, nous offrent de nombreux exemples. *Natura maxime miranda in minimis.*

Avant d'aller plus loin, il est nécessaire que je donne une brève description de quelques-unes de ces coaptations. 1. Chez la plupart des Céphalopodes Décapodes, le manteau est attaché en deux points à la base de l'entonnoir, par lequel est expulsée l'eau qui a passé dans la cavité palléale; sur l'entonnoir, se voient deux excavations dans lesquelles s'engagent deux saillies de forme parfaitement adéquate, qui se trouvent à la face interne du manteau Cette attache élastique, très solide, qui est du reste permanente pendant toute la vie du Mollusque, et ne peut être disjointe que par une traction assez forte, correspond parfaitement au bouton-fermoir à ressort, ou bou-

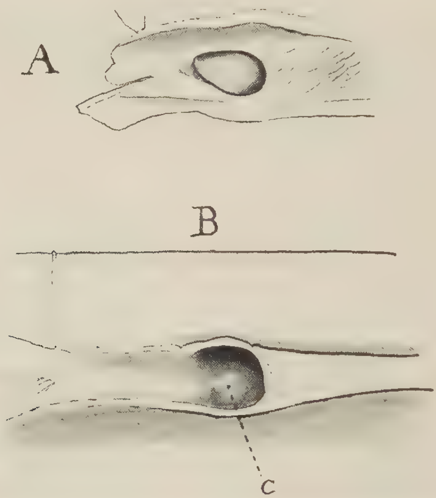


FIG. 2. Belostoma: *A*, extrémité distale de l'épimère mésothoracique droit vu par sa face dorsale, montrant le bouton saillant.

B, bord de l'élytre droitvu par sa face inférieure, montrant la cavité. *C*, où se loge le bouton. Gr. 10.

ton-pression, imaginé si je ne me trompe en 1886, dont on se sert pour fermer les gants et d'autres vêtements.

On retrouve le même dispositif chez tous les Hémiptères aquatiques formant le groupe des Hydrocorises (Naucores, Nèpes, Ranâtres, Bélostomes, Notonectes, Corises) pour attacher les hémélytres au thorax: l'épimère mésothoracique porte un bouton vaillant (fig. 2, A) qui s'engage dans un logement creusé à la face inférieure de l'hémélytre près de son bord externe (fig. 2, B); quand on les sépare l'un de l'autre en exerçant une traction convenable, on entend un petit claquement caractèristique, exactement comme

celui qu'on produit en défaisant un bouton de gant. L'adhérence des deux parties est assurée avec plus de certitude par un pavage écailleux qui revêt les pièces chitineuses, exactement dans les régions coaptées, et qui fonctionne comme calage élastique. L'appareil est propre aux imagos et n'apparait qu'à la dernière mue, lorsque les hémélytres sont complètement développés; sa constance chez les formes aquatiques, et celles-là seulement, correspond sans aucun doute à une nécessité de la vie dans l'eau; lorsque l'animal plonge, ses hémélytres restent étroitement collés au corps et ne se soulèvent pas.

2. Lorsque des pièces doivent glisser longitudinalement l'une sur l'autre d'un mouvement rapide sans se désunir, ainsi qu'il arrive pour des ovipositeurs ou des aiguillons venimeux, elles présentent un assemblage très ingénieux constitué par une languette saillante qui coulisse dans une rainure correspondante; la languette présente le profil d'un véritable rail à champignon plus large au sommet qu'à la base, comme dans l'assemblage comme en menuiserie sous le nom de queue d'aronde. On en trouve de beaux exemples dans l'aiguillon des Fourmis, entre les deux stylets porteurs chacun d'une rainure latérale et le gorgeret porteur de deux rails, les parties coulissantes étant munies de petits écailles chitineuses, fortement couchées vers la pointe de l'aiguillon, qui réalisent un calage élastique. L'ovipositeur des Locustes montre le même assemblage, les valvules inférieures présentant chacune deux rainures, dans lesquelles glissent les rails des valvules supérieures et internes.

La même coaptation, pour un tout autre but, se présente encore dans les élytres des Coléoptères; lorsque les élytres sont fermés sur le dos, il faut exercer une assez forte traction pour les séparer; on les assemble de nouveau en les ramenant au contact sur la ligne médiane. Le bord interne ou sutural, toujours épaissi, de l'un des élytres, présente une languette saillante (fig. 3), qui règne sur toute la longueur, et s'engage à frottement assez dur dans une gouttière correspondante creusée dans le bord de l'autre élytre. A l'extrémité antérieure des élytre, il y a presque toujours coaptation universe; le bord à languette présente un creux dans lequel s'engage une saillie qui termine le bord à gouttière. Mentionnons encore l'existence d'un calage élastique constitué par des aspérités qui recouvrent les parties coaptantes (fig. 3, B). Grâce à cet assemblage, les élytres fermés forment une cuirasse solide, difficile à disjoindre, qui recouvre exactement le dos du Coléoptère, et se coapte d'autre part avec les bords latéraux de l'abdomen. Il y a même des cas où l'adhèsion est tellement forte qu'on ne peut plus la rompre, et que l'Insecte est dit à élytres soudés. La coaptation est nulle ou mal développée chez les Coleoptères à élytres mous.

3. Chez beaucoup de gros Lamellicornes, en particulier chez les Lucanes, les pattes antérieures présentent des coussinets de frottement (fig. 4), constitués par des brosses de poils: une de ces brosses se trouve sur la hanche, dans la région où frotte le fémur, et figure un triangle allongé; l'autre dessine un ovale sur la face frottante du fémur. Ces coussinets manquent aux deux autres paires de pattes, et on ne voit pas trop quelle peut être leur fonction; toujours est-il que grâce à ces longs poils soyeux, le roulement du fémur sur la hanche est d'une remarquable douceur.

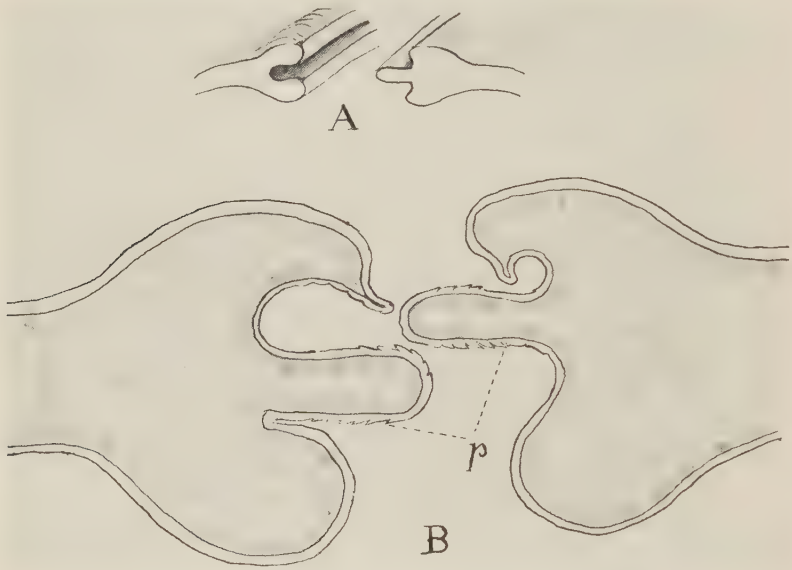


FIG. 3. *A*, schéma de la coaptation des élytres de Coléoptères, à gauche le bord élytral porte une rainure où coulisse la languette de l'élytre droit.
B, coupe transverse du bord sutural des deux élytres, imago de *Cassida viridis* L. sortant de la pupe; *p*, pavage écailleux assurant l'adhésion. Gr. 325.

4. Les pattes revisseuses de modèles assez variés que l'on rencontre chez les Nèpes, Ranâtres, Naucores et Mantedes, présentent un caractère commun: à l'état de repos, elles sont toujours fermées, à la manière d'un couteau de poche, la partie correspondant à la lame (tibia + tarse) s'appliquant d'une façon exacte sur la partie correspondant au menche (fémur), les courbures de l'une et de l'autre s'épousant parfaitement (fig. 5 et 7). Cet ajustement est très curieux á examiner en détail: chez *Nepa*, le fémur est creusé d'une forte gouttière qu'on voit bien dans les coupes

(fig. 6); le tibia se pose sur les bords de la rainure, le tarse en forme de griffe ayant un petit logement spécial vers la base du fémur; les bords des rainures fémorale et tibiale portent une brosse de poils serrés, plus grands et plus

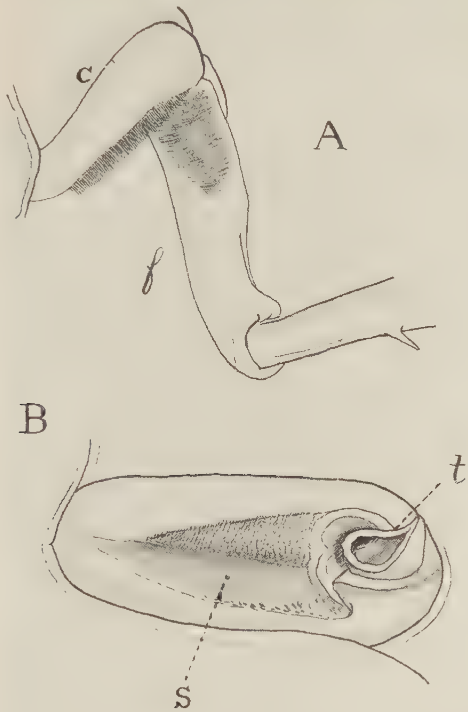


FIG. 4. *Lucanus cervus* L.: *A*, patte antérieure droite montrant les coussinets de frottement: *c*, coxa encastré dans le prothorax, montrant l'extrémité des poils du coussinet coxal; *f*, fémur avec son coussinet ovale. Gr. 5.

B, coxa vu de face, le fémur étant enlevé: *s*, surface triangulaire sur laquelle roule le fémur, et dont la partie supérieure porte le coussinet de poils; *t*, trochanter et articulation du fémur. Gr. 6.

forts que les autres poils du membre, et les deux pièces coaptantes adhèrent l'une à l'autre par l'intermédiaire de ces poils qui s'entrepénètrent. C'est exactement ce qui se passe lorsqu'on appuie deux brosses l'une sur l'autre, poils contre poils; cet ingénieux dispositif permet aux deux seg-

FIG. 5. Partie antérieure de *Nepa cinerea* L. montrant la coaptation des pattes antérieures rávisseuses; à gauche, la patte est dans la position de repos, le tibia rabattu sur le fémur, et le tarse logé dans une encoche de la base du fémur; à droite, le tibio-tarse est relevé et laisse voir la rainure qui court sur la face antérieure du fémur. Gr. 415.

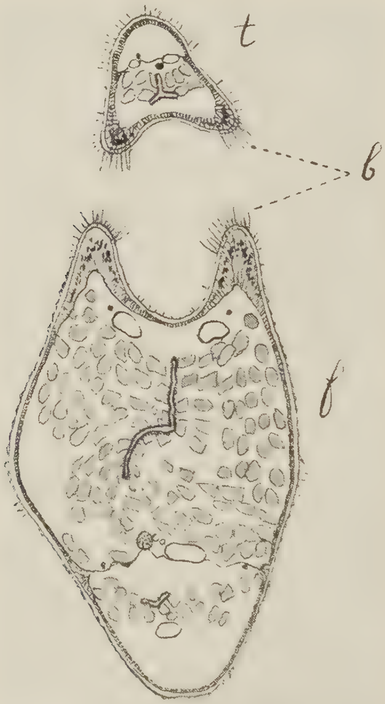


FIG. 6. Coupe transverse de patte ravisseuse presque fermée, imago de *Nepacinereas:* *b*, brosses de poils sur les bords du fémur (*f*) et du tibia (*t*). Gr. 40.

ments de rester appliqués l'un sur l'autre sans qu'une effort musculaire soit nécessaire.

Chez *Ranatra* (fig. 7), la courbe concave du tibia est exactement adéquate à la courbure convexe du fémure sur lequel il se rabat; la rainure fémorale qui occupe un peu moins de la moitié du segment est mathématiquement de la même longueur que le tibia; à l'extrémité proximale de la rainure se trouve une forte épine triangulaire derrière laquelle passe le tarse uniarticulé, et qui forme pour ainsi dire un taquet d'arrêt.

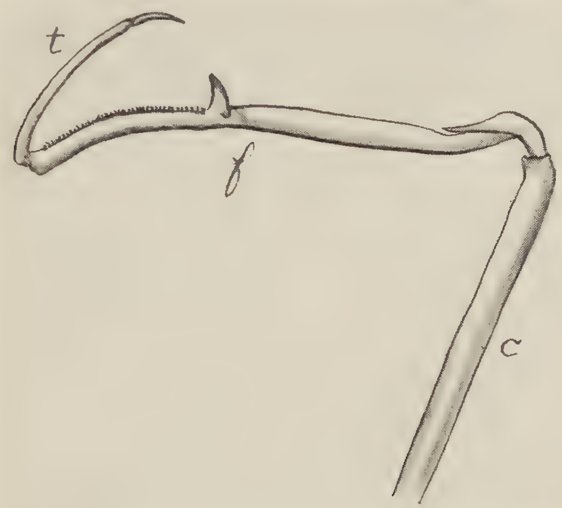


Fig. 7. Patte ravisseuse gauche de *Ranatra linearis* L.: *c*, coxa; *f*, fémur portant une forte épine d'arrêt; *t*, tibia et tarse. Gr. 6.

Chez *Naucoris* (fig. 8), la rainure fémorale est bordée d'une galerie de courts piquants d'un coté, d'une brosse de poils de l'autre; le tarse d'un seul article qui continue la courbure tibiale est logé dans une dépression faite exprès, qui épouse exactement son contour.

5. Les Coléoptères Longicornes présentent dans les deux sexes un appareil musical, qui est constitué d'une part par une râpe à stries transversales placée à la partie médiane du mésonotum, juste en avant du scutellum (fig. 9), et d'autre part par une arête transverse située à la partie interne du pronotum; par des mouvements de haut en bas du prothorax, l'arête frotte contre la râpe en produisant un bruit peu intense, en particulier lorsqu'on vient de capturer l'Insecte. La râpe, élégamment encadrée d'une bordure

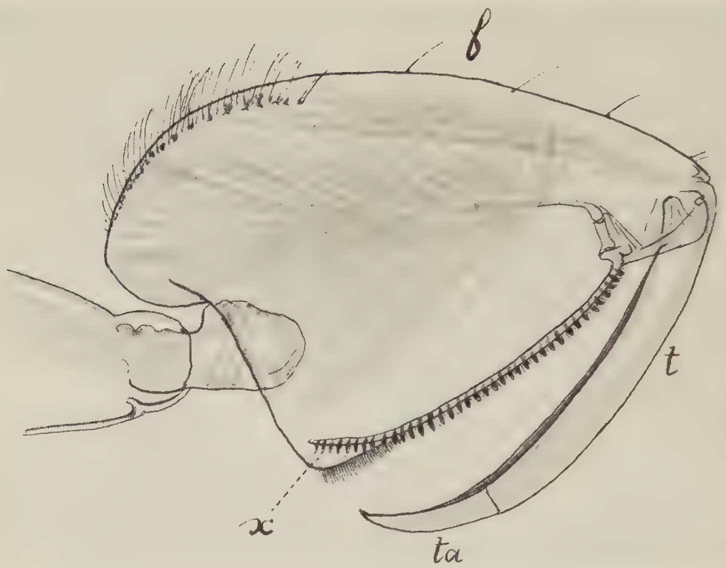


FIG. 8. Patte antérieure ravisseuse de *Naucoris maculatus* Fabr.: *f*, fémur volumineux et aplati; *t*, tibia; *ta*, tarse uniarticulé; *x*, logement spécial de l'extrémité du tarse. Gr. 40.

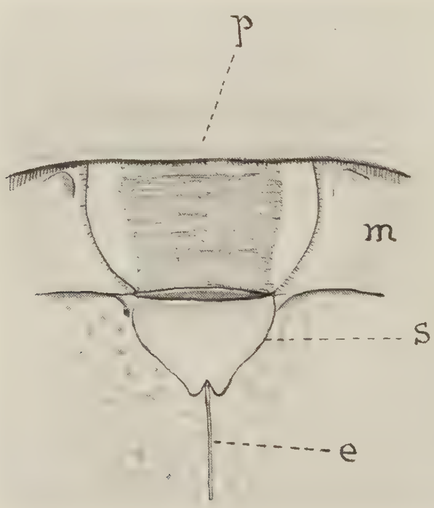


FIG. 9. *Cerambyx miles* Bon., vue dorsale de la râpe musicale: *e*, bord sutural des élytres; *m*, mésothorax portant la râpe entourée de son cadre; *p*, bord postérieur du prothorax, sous lequel se trouve l'arête de frottement; *s*, scutellum. Gr. 9.

lisse, a des nombreuses stries d'une extraordinaire finesse que l'on n'aperçoit qu'avec un éclairage spécial; Landois[7] en a compté 238 sur la râpe du *Cerambyx cerdo.* On ne sait pas si cet appareil musical joue un rôle quelconque dans la biologie des Longicornes.

6. On pourrait citer encore maints exemples de coaptations, tous aussi remarquables que les précédents: l'appareil saltatoire ventral des Elatérides, la rainure qui se trouve le long du rostre des Curculionides et où se loge si exactement l'article basilaire de l'antenne lorsque celle-ci se replie, les très variés appareils d'accrochage des ailes pendant le vol chez les Rhynchotes, les Hyménoptères, les Lépidoptères, les crochets d'union des barbules dans les plumes locomotrices des Oiseaux, l'ajustement des fémurs antérieurs des Phasmes et de la tête dans la pose de repos diurne (fig. 10), etc.

Il est prouvé que les coaptations sont contenues en puissance dans le patrimoine héréditaire, car elles apparaissent déjà chez l'embryon ou la

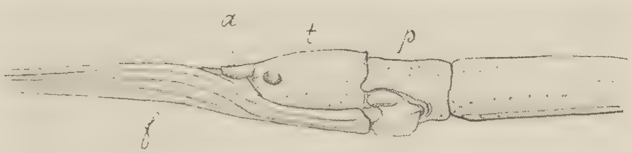


Fig. 10. Vue de profil de la région antérieure de *Carausius morosus*, dans la position de repos diurne: *a*, base de l'antenne gauche s'engageant dans la gouttière formée par les deux pattes antérieures; *f*, fémur antérieur exactement appliqué contre la tête; *p*, prothorax; *t*, tête. Gr. 3, 4.

pupe, bien avant tout usage. Les deux parties qui, plus tard, seront coaptantes, se développent indépendamment l'une de l'autre et même en des points éloignés, dans toute leur perfection; puis, au moment de l'éclosion, elles se déplissent, prennent leur forme, se rejoignent et s'ajustent exactement du premier coup. Ainsi, pour ne prendre qu'un exemple, les pattes ravisseuses des Nèpes et Ranâtres sont chez l'embryon, non pas reployées dans la position qu'elles prendront chex l'animal éclos, mais complètement allongées comme du reste les autres pattes; cependant on distingue très bien, chez les embryons avancés, la rainure longitudinale du fémur et la petite encoche spéciale où viendra se loger le tarse. Dès l'éclosion, lorsque la cuticle s'est déplissée et que le corps a pris sa forme définitive, bien qu'encore d'une façon parfaite et commence à fonctionner. De même pour les coaptations spéciales aux imagos, telles que le bouton-pression ou la rainure à

[7] Zeit. f. wiss. Zool., 17, 1867, p. 127.

languette; les deux parties se forment chez la pupe, largement separées l'une de l'autre par la cuticule nymphale qui empêche tout contact; aussitôt après la mue imaginale, s'opère l'ajustage et la coaptation est apte à fonctionner dès que la cuticule s'est durcie.

Comment peut-on comprendre la genèse des coaptations? Si insignifiants que paraissent ces minuscules détails, cette question est une des énigmes de la Biologie. Ce qui est frappant, c'est que ces dispositifs ont souvent l'air, si je puis m'exprimer ainsi, d'avoir été conçus et exécutés par un ouvrier, c'est à dire que les solutions données par la Nature aux nécessités des êtres vivants sont des solutions analogues à celles que l'ouvrier humain a trouvées, par son intelligence propre, lorsqu'il a eu à résoudre des problèmes à peu près semblables (du reste sans copier la Nature, car la plupart du temps, il ignorait ce que celle-ci avait fait). La solution de la Nature ne diffère de celle de l'ouvrier que par sa perfection bien plus grande, sa souplesse et sa solidité, son élégance et son luxe de petits détails.

Les solutions de l'Homme envisagent bien entendu un but ou un usage déterminé, ce que l'on appelle une fin intentionnelle en langage philosophique; les oeuvres de la Nature ont aussi une fin, qui est leur fonction, à laquelle elles sont pour la plupart parfaitement adaptées par leur structure, leur physiologie et leur coördination. Ainsi l'oeil a pour fin la vision. Que l'on dise que l'Homme voit parce qu'il a des yeux, au lieu de dire qu'il a des yeux pour voir, c'est un artifice de langage qui ne change rien au fond des choses. Cette finalité allait de soi dans la conception créationniste: Dieu, en créant chaque espèce naturelle (la forme Sauterelle, la forme Hydrocorise), lui avait nécessairement donné tout ce qui lui fallait pour vivre dans le milieu auquel elle était destinée; le problème des adaptations était ainsi résolu d'un seul coup, en bloc. Mais l'avènement du transformisme a amené un changement complet dans l'interprétation de la finalité: la grande majorité des biologistes, dans les cinquante ans qui ont suivi l'apparition du livre de Darwin sur l'*Origine des espèces*, ont été de purs mécanistes: si les organes ont une fin, disent-ils, c'est parce qu'ils remplissent un rôle utile, une fonction, dans l'organisme coördonné; ils ont atteint leur état actuel par le jeu de causes naturelles (facteurs de l'évolution), la sélection impitoyable n'ayant laissé subsister que des organes utiles ou d'une inutilité peu ou point gênante, jamais d'organes nuisibles à l'espèce. Les biologistes spiritualistes et les théologiens, tout en acceptant l'évolution, croient à une causalité finale de l'Univers, à un Esprit créateur supérieur et antérieur à la Nature, qui dirige celle-ci par les lois qu'il a posées, mais sans intervenir directement; *melior est causa causae quam causa causati*, dit un vieil adage scolastique; ils conviennent que tout

ce qui se passe dans le monde relève de causes efficientes ou secondes, dont l'étude est l'objet de la science.

Au point de vue philosophique, il y a sans doute un abîme entre les deux concepts: pour les premiers, la finalité des organes est la résultante du hasard des variations et de la rélection; pour les seconds, l'évolution est dirigée par la volonté d'un Esprit, suivant un plan *préconçu et ordonné*, par l'intermédiaire des causes secondes; la finalité est donc intentionnelle, qu'il s'agisse d'un microscopique rail de guidage d'un aiguillon d'Abeille ou d'un oeil d'Oiseau; pour le théologien, l'harmonie générale de la Nature, les merveilleux résultats des causes efficientes, constituent la preuve la plus apparente de la causalité finale. Mais au point de vue scientifique, les deux concepts se rejoignent absolument; pour expliquer la formation des coaptations, il importe peu qu'on soit spiritualiste, moniste ou agnostique, qu'on croie ou non à une causalité finale; on n'a le droit que d'en rechercher les causes efficientes (facteurs de l'évolution), exactement comme un physicien ou un chimiste qui étudie les phénomènes de sa spécialité; si on ne les trouve pas, il ne reste qu'a reconnaître notre ignorance et à faire appel à un avenir mieux informé sur le nombre et la valeur de ces causes efficientes.

De toute évidence, ce ne peut être une variation germinale fortuite qui fait apparaitre d'un coup le bouton-pression et son logement, les deux brosses des pattes de Lucane, etc. On comprend bien qu'une mutation conditionne un changement de couleur, de symétrie, de nombre, de taille, de vigueur constitutionnelle, voire d'instinct, cest à dire quelque chose d'indéterminé au point de vue fonctionnel, sans relation avec l'utilité, dont l'animal s'arrange comme il peut; les innombrables mutations connues sont de ce type. Comment pourrait-on imaginer une mutation aveugle produisant d'un coup un résultat tel qu'une coaptation, aussi précise dans sa structure que dans sa fonction?

Pense-t-on à une origine mécanique par pression et moulage réciproque, dont le résultat est devenu ensuite héréditaire? Outre que ce setait admettre l'hérédité d'un caractère mécanique acquis, ce qui est bien peu vraisemblable, cela n'expliquerait rien; beaucoup de coaptations sont des structures beaucoup trop raffinées pour être comparées à des accidents d'origine sûrement mécanique, comme les sillons grossiers que creusent à la surface d'un os la pression d'un vaisseau ou le frottement d'un tendon. Comment la râpe mésothoracique d'un Longicorne et son frottoir prothoracique, les appareils d'assemblage des ailes et des élytres, le rail et sa rainure, pourraient-ils être le résultats de pressions, de frottements ou de tout autre acte mécanique? Ce serait incompréhensible, d'autant plus que

beaucoup de ces coaptations, dans le cas spécial des Insectes, sont propres aux imagos, dont le tégument est fixé une fois pour toute et ne peut plus être déformé; il en est aussi qui ne remplissent un rôle que pendant quelques minutes de la vie (ovipositeur des Sauterelles). Admettre qu'une coaptation, ou un organe comme l'oeil, ou une forme comme celle du Poisson avec ses courbures, ses plans stabilisateurs et ses nageoires, provienne des jeu de forces naturelles agissant sur la matière organique, *sans agent directeur*, c'est attribuer à celle-ci une capacité *sui generis* de répondre à des excitations simples par l'édification mystérieuse de machines complexes et coördonnées, ce qui nous remène au finalisme d'Aristote ou peu s'en faut.

Il ne reste qu'une hypothése je ne dis pas satisfaisante mais possible: les coaptations seraient le résultat d'une évolution dirigée par l'utilité, à partir d'organes très simples, mais déjà utiles; toutes les variations qui se transmettront réaliseront forcément des améliorations de l'état primordial ou au pis aller des modifications indifférentes, car toutes les variations défavorables déterminent la mort des individus qui les présentent et s'éteignent. Il est évident qu'un simple défaut à une glissière d'ovipositeur empêche absolument la ponte, d'ou élimination certaine de la lignée désavantagée; il est possible que la coaptation des pattes ravisseuses, voire même que les coussinets de poils des pattes de Lucanes ou la râpe musicale des Longicornes, aient une importance que nous ne soupçonnons pas; nous sommes très mal placés pour juger de l'utilité de ces petits détails pour la vie de l'espèce. La morphologie comparée des coaptations dans un groupe naturel n'est pas défavorable à cette manière de voir; il y a chez les Locustes à ovipositeurs courts des glissières assez frustes mais qui suffisent dans le cas particulier; dans le groupe des Hémiptères aquatiques, il y a des appareils beaucoup moins parfaits que le bouton-pression (Corises), mais qui fonctionnent néanmoins. L'oeil humain, qui est assurément un étonnant appareil d'optique ayant la vision comme fin, dérive d'une simple tache pigmentaire innervée; dans la lignée des ancêstres vivant à la lumière et dépendant d'elle pour chercher leur nourriture à la vue ou pour se protéger, toutes les variations qui ont pu se produire autour de l'oeil ou à son intérieur n'ont réalisé que des étapes graduées à la fois dans la structure et dans l'utilité, ou au pis que des modifications indifférentes (comme les variations de couleur de l'iris); toutes les variations défavorables, produisant une diminution de la vision, ont abouti à la décadence et à la mort des espèces, et nous ne nous les connaissons pas, ou bien les ont contraintes à chercher un milieu obscur, où elles pouvaient se passer de la fonction (Poissons aveugles, Reptiles endogés, Taupe, etc.).

Sans doute c'est attribuer une grande valeur à la sélection, que l'on a une tendance à notre époque à sous-estimer, et à réduire à un rôle conservateur. A cela on peut répondre que son importance est prouvée avec une rigueur presque expérimentale par la cessation même de son action, ce que Weismann a appelé la *panmixie*; ce processus est bien connu d'une part chez les animaux domestiques protégés par l'Homme et d'autre part chez l'Homme lui-même, soustrait par sa vie sociale à la lutte contre la faim, le froid, les carnassiers, et aussi par la médecine et les institutions charitables aux conséquences des malformations et des maladies microbiennes. Les premiers renferment des quantités de races (Chiens de luxe, animaux gros, Oiseaux incapables de voler) qui ne vivraient pas une semaine à l'état de nature; le second, surtout à l'état civilisé ne compte plus les caractères presque pathologiques des dents, des poils, des glandes mammaires, des yeux, etc., qui auraient rendu sa vie impossible dans les âges préhistoriques. Il n'est donc pas invraisemblable d'admettre que la sélection a une influence assez grande pour diriger l' évolution de petits appareils qui ne sont peut-être insignifiants qu'en apparance, et qu'elle puisse jouer le rôle de l'ouvrier qui perfectionne graduellement son oeuvre.

J'ai exposé loyalement, je pense, la thèse des sélectionnistes; je dois dire que, pour ma part, elle ne me satisfait pas pleinement. J'ai peine à croire que des mutations de hasard du patrimoine héréditaire, même canalisées par la sélection, puissent édifier un organe complexe impliquant un nombre énorme de coördinations, tels que l'oeil et certaines coaptations. Je trouve incompréhensible que des êtres aussi différents qu'un Pecten, qu'un Céphalopode et qu'un Poisson, aient acquis des yeux d'une perfection comparable, par le simple jeu de variations fortuites superposées (argument de Bergson, dans *l'Evolution créatrice*, 1907); c'est d'autant plus incroyable que si les yeux sont indispensables au Céphalopode et au Poisson, qui chassent à la vue, le *Pecten* qui se nourrit passivement pourrait fort bien s'en passer, comme tant d'autres Lamellibranches.

Quant à l'importance attribuée plus haut à la sélection, c'est pure hypothése il est vrai, mais on ne saurait positivement la critiquer, car on est bien peu fixé sur la valeur du facteur sélectif. D'un côté l'on voit des variations considerables (espèces polymorphes) qui subsistent côte à côte sans qu'il y ait entre elles de concurrence visible; d'un autre côté, on connait le cas de l'*Amphidasis betularia* dont la variété mélanique *carbonaria* est en voie, depuis 70 ans, de se substituer au type tacheté dans maintes régions; ailleurs encore la sélection a un rôle conservateur, en éliminant les individus les plus éloignés de la moyenne raciale. Nous ne savons pas du tout si, toutes choses étant égales, une légère mutation favorable d'un appareil coaptatif

peut constituer un avantage qui donne prise à la sélection, ou bien si cela se perd dans la masse des contingences.

Peut-être à cause de ces incertitudes, on a le sentiment obscur qu'il manque quelque chose à nos conceptions de l'évolution et à ses causes efficientes; à tort ou à raison, les mutations fortuites et la sélection, qui sont les seuls agents reconnus de perfectionnement, nous paraissent insuffisants. La nécessité d'un facteur nouveau, interne ou externe aux organismes, régulateur des mutations et capable de les diriger vers une fin, se fait surtout sentir lorsqu'on étudie des organes complexes comme les yeux, les organes photogênes des animaux abyssaux, les organes électriques des Poissons ou les coaptations, ou lorsqu'on contemple les ornementations d'une si rare et d'une si inutile beauté des plumes du Paon et de l'Argus. Du reste, je n'entends par là rien de métaphysique, aucune entéléchie aristotélienne ou leibnizienne, mais quelque loi générale, qui a échappé à nos prédécesseurs, et qui reste à découvrir.

INHERITANCE IN UNICELLULAR ORGANISMS

H. S. JENNINGS

The Johns Hopkins University

Of the results of the study of inheritance in unicellular organisms, I can attempt only a summary of certain matters that appear of general interest, particularly to those occupied primarily with the problems of race improvement.

In man and in all higher animals the problem of racial alteration, and indeed all problems of genetics, are enormously complicated by the mixture of two individuals at reproduction, accompanied by a sorting over and recombination of the materials on which the diversity of characteristics depend. This results in a tremendous diversity among the descendants, purely as a matter of kaleidoscopic regrouping; it becomes extremely difficult to distinguish among these any actual racial changes, any changes due to alterations in the hereditary substances; difficult to study any of the phenomena of inheritance except those resulting from this sorting over and regrouping. In consequence, inheritance under the name of Mendelism has largely come to be identified as simply the results of this sorting over and recombination.

In unicellular organisms this sorting and recombining is omitted for long periods; descent for thousands of generations is from a single parent; all the progeny have the same germinal material or "genes" as had the parent. We are therefore enabled to observe what inheritance is when quite free from Mendelism; we may examine any hereditary changes due to alterations in the germ plasm, quite uncomplicated by kaleidoscopic regrouping of the germinal substances.

When we follow for long successions of generations the descent of organisms multiplying thus from a single parent, two impressions are very strong. First, we are astonished at the uniformity, the constancy, shown by the hereditary constitution of the race. One is almost led to believe that it is a fixed, an unchangeable, thing; some investigators that have devoted themselves for years to this work still hold that it *is* an unchanging thing. Second, in spite of this uniformity of the hereditary constitution, we are struck by the variety, the sometimes very great diversity, among the individuals all possessing this same hereditary constitution; all arising

from the division of a single parent. To take the case first worked out, in Paramecium there are many races differing very slightly in size, and these differences are inherited completely, if we compare the mean sizes of the different races. In each race taken by itself there are similar or greater differences in size among the individuals. But *these* differences are not inherited at all; large and small individuals of the stock produce progeny not differing in the least. In some other protozoa the characteristics are more diversified. In Difflugia there are similar diverse races, differing in many structural features, and within the single race we find the same structural diversities; differences in the number and arrangement of the spines; in the length of the spines, and the like. But these differences within the race appear not inherited; an individual with many spines and an individual with none produce progeny of the same average character, if they belong to the same stock; and so of other characteristics. We have in this respect a parallel to the spotting, to the distribution of colors, in some mammals; the individuals may differ in most characteristic ways, but the differences are not inherited. Yet, in our Difflugias, and in Paramecium, identically the *same* differences, when characteristic of different *races*, *are* inherited.

This great diversity of individuals all possessing the same hereditary constitution appears worthy of particular notice by those interested in the improvement of a species. There is a popular impression that genetics, that eugenics, is attempting to teach that our characteristics—that all that we are—are predetermined in the germ plasm; that with the germinal constitution which we receive all our characteristics—our fate—are decided. This is not true in the Protozoa; I venture to say that there is no ground for asserting it to be true in man. Merely because we inherit a certain characteristic, we are not required to *have* it. In our Protozoa, individuals with the same hereditary constitution possess most diverse characteristics. It is not inherently impossible that from the same stock of Difflugia, all with the same hereditary constitution, we could produce two sets—one exhibiting always numerous large handsome spines, and producing progeny with such; the other always with few, stunted, or lacking spines, for these diversities are seemingly not inherited,—though we do not know just how to do it yet.

But not *all* characteristics show this "personal" diversity, independent of the germinal constitution. In Paramecium, the form and structure do not show it; they seem always fully determined by the hereditary constitution; while *size* does show it. In Difflugia, the number, size, and arrangement of spines is thus largely subject to personal variation, while bodily

size is not; body form is not; size, structure, and number of teeth are not. In every organism it is necessary to determine by observation which characteristics are fixed by the germinal constitution, which ones are not; and there are very great diversities in the *degree* of fixation by inherited constitution, in the readiness to be modified by the environment, in different characteristics of the same race.

Though the individuals of a race thus vary, there is, as we remarked, a high degree of constancy, of uniformity, in a given germinal constitution; experiment for thousands of generations may reveal no alteration in it. There are many lower organisms that have thus been thoroughly studied for long periods while reproducing from a single parent, in which no single diversity in hereditary constitution has been discovered. There are indications, as we know, that in man and higher animals the same sort of reproduction would show similar constancy and uniformity. When two individuals are derived from a single egg we have essentially the same phenomenon as in production from a single parent; they receive the same germinal material and are now in physical features almost exactly alike, forming the so-called identical twins. In the armidillo, as Newman and Patterson show, several offspring arise from a single egg and these show the same astonishing similarity that we see in identical twins in man. In the Protozoa, identical twins occur in sets of millions each. In man, as identical twins show, form and structure appear to be very accurately fixed by the germinal constitution rather than by the action of the environment, while behavior and physiological processes are not.

Yet permanence of inherited constitution turns out not to be the whole story after all, in reproduction from a single parent. The "personal" differences among members of the same stock, *apparently* quite non-heritable, turn out, on prolonged study to be not absolutely so. Breeding organisms particularly favorable for such study, where growth changes and environmental alterations during life are excluded, and following uniparental reproduction for long periods, we find in some cases that after a great number of generations slight hereditary differences have appeared. Selecting on the one hand individuals possessing a certain character, on the other those not possessing it, we find that after a long period we have obtained, from a single parent, stocks differing hereditarily in these respects; the differences persist from generation to generation. So in the rhizopod Difflugia I finally obtained as descendants of a single parent a number of stocks showing different combinations of diverse hereditary characters. Some were large with large spines; some large with small spines; some small with large spines, and the like. Similar inherited differences have been

shown to arise in Arcella by Hegner, and in Centropyxis by Root; inherited physiological diversities have been shown by Middleton to arise in infusoria.

It appears thus that the "personal" differences within a stock are not after all entirely non-heritable, as they appear to be if we study them for a few generations. There is in the very long run a low degree of correlation between the "personal" characteristics of the parent and those of the offspring, even within the same stock. Here we have a phenomenon of inheritance quite apart from Mendelism. So far as it goes it tends to rehabilitate the Galtonian theory of inheritance as a correlation between the bodily characteristics of parent and offspring, quite independently of chromosomal recombinations.

It must not however be passed over in silence that in many organisms, multiplying by uniparental reproduction, after long study, no inherited differences are found to occur in a stock; the hereditary constitution appears permanent.

Where inherited diversities do occur, where do they arise, and how are they brought about?

On this we know in the higher Protozoa very little. In Arcella, Hegner found that the number of nuclei may be increased by a division of a nucleus without a division of the body, or decreased in the reverse way. Such a change in the number of the nuclei induces a change in the size of the cell body, and correlated with this other changes occur; the number and size of the spines change. Thus differentiated races arise sometimes through these changes in the number of the nuclei. It is clear that not all the inherited variations arise in this manner, for there are in Difflugia diverse combinations of characters; large races with large spines; other larger races with smaller spines. Aside from this, there is little but speculation as to the origin of the hereditary differentiations.

May diversities in the environment bring about hereditary differentiations? Here again the conditions are parallel to those already described. In many cases environmental agents have been tested for many generations; they readily modify the individuals on which they act; but as soon as the original environment is restored, all these modifications are lost; there is no "inheritance of acquired characters." Such has been my own experience in extensive experiments with chemicals on Paramecium. Such is the large, obvious fact in most work of this sort. Other investigators have been more successful. Middleton found that when a part of the progeny of a single individual of Stylonychia are kept at a high temperature, the others at low temperature, the two become permanently diverse in rate of fission. The fact that we are here apparently dealing with inherited

differences in what may be called *vitality* makes doubtful the bearing of these observations on characteristics of other sorts. Middleton has recently observed similar permanent changes as a result of subjection to chemicals. By subjection to chemicals for long periods, Jollos has induced hereditary changes of resistance to these chemicals in Paramecium. The greater resistance induced lasted for only a limited number of generations as a rule, but the longer the given chemical acted the longer did the inheritance last. This would suggest that if the action of the environmental agent were very long continued, the inherited alteration might become as permanent as any hereditary character, though Jollos doubts that this would occur.

If we turn from what we may call the *higher*, and the free-living, unicellular organisms to the simpler ones, the picture appears to change greatly, with relation to the inherited effects of environmental action. In the bacteria and some of the pathogenic protozoa, great numbers of cases of inherited modifications due to the environment are reported; changes in resistance, in virulence, and the like. Here the difficulty of being certain that we are dealing with progeny of a single individual is very great, so that many hold that these results are largely deceptive. It is asserted that the experiments began with a mixture of races of diverse hereditary characteristics. Some of these thrive under certain conditions and therefore give character to the cultures; others thrive under other conditions, giving a new character to the cultures; this alone is held to be the explanation of the apparent change in hereditary characteristics due to environmental differences. There are investigators who urge strongly this interpretation for all cases.

As this is a field in which my own work has not lain, I shall not take it up in detail but will make the following general remarks. First, in some of the investigations the evidence appears very strong that the observed hereditary changes are actually the result of environmental modifications. Second, if we accept generally the accounts of the phenomena in bacteria, as set forth for example in Adami's "Medical Contributions to the Theory of Evolution," we must conclude that in these elementary organisms hereditary modification due to environmental action is rather readily produced; and that it is adaptive in character; that here in the lowest organisms "acquired characters are inherited" on a rather large scale, and must be an effective factor in evolutionary change. These conclusions I think have a very great body of evidence for them. If they are correct, the ground for the difference in these respects between them and the higher unicellular organisms, as well as multicellular organisms, becomes a problem of great interest; one is inclined to believe that the difference must be one of degree only.

Biparental reproduction occurs of course in many of the unicellular forms but its results have been little studied. There is some evidence that it produces diversity of the same sort seen in higher animals, through the sorting and recombination of the germinal materials.

In sum, the study of inheritance in unicellular organisms permits us to obtain and examine great numbers of individuals having identically the same hereditary constitution. "Personal" differences of marked character occur among such individuals, emphasizing the fact that heredity by no means fully determines the characteristics of organisms; all characters are due to the interaction of germinal materials with the other conditions, and are dependent on both. A remarkable constancy and uniformity of the hereditary constitution itself is discovered; a constancy so great as to give the impression that no heritable changes occur. But in some of these organisms, in the long run, it is found that the diverse "personal" features have a faint tendency to be inherited; gradual changes in hereditary constitution occur in the passage of a great number of generations. In the lower unicellular forms, particularly the bacteria, such hereditary change appears to result from the action of the environment, "acquired characters" being inherited, and that not so very uncommonly. But this conclusion is rendered somewhat insecure by the difficulty of determining critically the facts in these minute organisms. In the more complex unicellular forms, as in the multicellular forms, hereditary change resulting from environmental action appears rare if not absent.

EVOLUTION OF THE CHROMOSOME COMPLEX

C. E. McCLUNG

University of Pennsylvania

It is significant of the development of modern biology that a cytologist should be invited to discuss the nature of chromosome organization and descent at an eugenics congress. By this circumstance there is shown a real recognition of the relation existing between the material substratum of hereditary processes and their visible somatic manifestations. This approach between fields which, two decades ago, had little in common is most gratifying and its fruitfulness is shown in the many important genetical advances made each year. Correspondingly it becomes increasingly important to determine accurately the character and range of the cytological phenomena by which genetical results are thus explained.

The chromosome theory of heredity is now so firmly established that only an entire revolution in our conception of cellular organization can displace it as a formal explanation. As new facts accumulate in the study of inheritance they fall at once into relation with others because there now exists an adequate conception of the germ cell mechanism. Facts, at first thought to discredit the chromosome theory, have, with increased knowledge, been found to relate to special conditions whose explanation in turn has broadened the original conception. Thus, for biology, the chromosome theory serves to correlate and promote advances in knowledge much as the atomic theory did for chemistry.

Since the significance of an evolution of the chromosome complex is bound up with the functions of the chromosomes in individual development, it is important to recall our understanding of the chromosomes in this rôle. It is again a question of the relation between ontogeny and phylogeny. Briefly stated my conception is as follows: The chromatin is that portion of the cell most immediately concerned with the control of processes which result in the formation of structures and the exhibition of functions which are called characters. This chromatin is differentiated into structural units, each of which has a particular function to perform in relation to the series of functions inherent in the entire chromatin of the cell. These units are grouped into chromosomes, in which, at their greatest extension, they are linearly arranged. The chromosomes in number, form and size

are constant for the species and thus give evidence of the specific character of their constituent parts. Individually they show constant differences within the cell which is taken to be an indication of the unlikeness of their constituent units.

In the present state of our knowledge it is hazardous to attempt the formulation of theories of chromosome relations between widely different forms of animals. It is much safer to enquire into the conditions obtaining within limited and well-understood groups. With this thought in mind I purpose to review briefly those facts which have developed during the last two decades in extensive studies made by myself and students upon the chromosomes of certain Orthopteran groups. With these will be compared the results of other investigations which seem to contribute to a wider knowledge.

The outstanding fact which has been revealed by this study of practically all of the genera of North American Acrididae is that the entire family possesses a characteristic chromosome complex, the most marked feature of which, in nearly every case, is a common number. It is difficult to over-estimate the significance of such a fact in relation to the phylogeny of the group. There are scores of genera, hundreds of species, billions of individuals, all containing multitudes of cells, each of which possesses the same numerical complex of chromosomes as every other cell in all the innumerable host. And what is true of the living population we must assume to have prevailed in the endless generation of past geological ages, because this uniformity in members of divergent terminal series could not eventuate from disharmonious ancestral groups. It passes the imagination to conceive an organization of material so exact as to accomplish this endless uniformity and yet, in every mitotic division, is exhibited the means by which it is done. Each chromosome there visibly reproduces itself. The chromosomes now existing are the direct lineal descendants of similar ones down through the ages. There is absolutely no logical escape from this conclusion in the light of existing evidence. However much conditions may vary in the other groups, within the Acrididae we have this demonstration of the phylogenetic continuity of the chromosome complex. But if the chromatin is indeed the differentiated congeries of character determiners whose nature is, in part, revealed by the form of integration into chromosomes, then we should find, in various species, definitely recognizable chromosome distinctions. These, indeed, occur and are of the most exact taxonomic significance as will later appear, but, so far as the totality of the complex is concerned, practically all the evidence speaks for it. In species after species the male animal shows, in every cell, a group of twenty-three chromosomes while the female cells have always twenty-four.

Not only are there always the same numerical series of chromosomes in these Orthopteran cells, but they occur in an approximately like size seriation, ranging through proportionately equal steps from the smallest to one five to ten times its size. Despite a considerable range in actual dimensions of chromosomes in different species, there is always found this gradation from the smallest to the largest. How far this criterion may be used to determine actual homologues throughout the taxonomic group is as yet undetermined, but the weight of evidence would indicate its value in a general way. If it were exact we could, of course, homologise any well defined element like the smallest chromosomes in all the species of the family. Whenever such definite identification becomes possible our means of structural analyses will be greatly increased. As yet the only definitely recognizable chromosome in all the species is the accessory chromosome. This may be identified beyond any question in every one of the many individuals studied.

It is clear from these considerations, therefore, that, although we are dealing with the same series of chromosomes they must be individually of a different internal constitution in different species if they are indeed the groups of determiners we conceive them to be. Such internal differences may or may not be visible in the general configuration of the element, and, as yet, we have no means of measuring such differences so that they may be correlated with taxonomic characters. Although these internal changes may not with certainty be determined there are species whose chromosomes show by their behavior that they have undergone some structural modification. Perhaps the most marked instances of this are where an actual difference in the number of chromosomes appears to exist. In the Acrididae of North America, which we have so far studied, this numerical variation is principally due to fusions between certain non-homologous members of the complex, which also breaks the size seriation. Studied alone and without consideration of other members of the group, such cases as have been described for Hesperotettix, Mermiria, Chlœaltis, and Chorthippus would seem to be evidence against the generalization of a family constancy for the chromosome complex, but, when properly understood, are found to be merely instances of a chromosome reorganization which has brought about a more or less temporary union between certain of its members. Since this tendency to form multiples resides definitely in certain taxonomic groups we must regard this behavior of the chromosomes involved as an evidence of a peculiarity in their organization. That it is perhaps of the same nature wherever found is suggested by the fact that the euchromosome multiples tend to involve the largest members of the complex and that additional ones follow down the size series.

While in the Acrididae evidences of internal reorganization manifested by numerical and size changes are generally confined to a reduction in number by fusions, in other groups it is found that the total series of chromatin elements may be maintained in the presence of marked numerical chromosome variations. Thus it has been found by Holt that the type number of six in Culex may be multiplied in a single cell to seventy-two by successive duplications of the individual chromosomes. The diploid number of forty in the pig may be increased to fifty-eight by fragmentation, according to Hance. By non-disjunction of homologues it is found by Bridges that the number in Drosophila may be raised or lowered by one. In various forms there are also multiple complexes, and supernumeraries. Blakeslee and his fellow workers have noted twelve distinct mutants of Datura, each of which shows a different triple representation of homologous chromosomes in the diploid complex making 25 instead of 24. A thirteenth mutant has four homologues or a tetraploid complex, and it differs from all the others.

Wherever these variations occur, however, it is found that the total normal series of chromatin elements is not reduced, although there may be combinations, duplications, additions or rearrangements. The series, in whole or in part, tends to maintain itself. This is especially true of the germ cells where it would appear from all evidence, genetical and cytological, there must be maintained a full complement of the chromosomes. Additions may be made to this normal number of all members of the complex, but it may not, without injury, be reduced. Distinct somatic differences sometimes accompany such modifications of the germ cell chromosomes, but the changes are not destructive of the coördinated action of the complex. On the other hand there is some evidence to indicate that somatic cells may suffer more extensive chromosome modifications without injury to their specific action.

While the conditions of the chromosomes in the Acrididae are thus comparable throughout the family, on the basis of our present knowledge, comparisons between even the saltatorial families of Orthoptera are not at present possible. It is here that we may hope, with increased knowledge, to gain a conception of the phylogenetic history of a chromosome group. Already the accessory chromosomes may be homologised definitely wherever found. If it is true that in one element of the complex we have a definitely integrated portion of the idioplasm, the presumption is strong that there may be other recognizable chromatin units. That the Acrididaean numbers 23 and 24 appear in the Gryllidae may not be without significance, therefore.

How the variations in number of chromosomes, marking the difference in the form of chromatin organization came about, we have no direct

indication. It may be noted, however, that the changes in the Acrididae so far observed are all concerned with reducing the number of free units by combinations to produce multiples. Sometimes these reductions are permanent as in Chlœaltis, Chorthippus, etc.; sometimes they are occasional, as in Hesperotettix viridis. That such combinations are indicative of a definite tendency is shown by their prevalence in numerous species of the genera concerned. Also it is significant that such combinations begin with the largest pair and successively involve the series in this order, so long as multiples are formed. These facts indicate that some general principle of chromosome organization is expressed in this tendency of chromosomes to form unions. When this does occur, however, there is a break in the uniform series of chromosome sizes commonly found in a cell, and we should expect to discover some later reorganization of the elements in case of permanent fusions. This does not seem to be manifest in the species so far studied. One other change in chromosome structure may be important. In most species of Acrididae, the attachment of fibers to the chromosomes in the metaphase is terminal but occasionally, as in Circotettix and Trimerotropis, it may be median or subterminal. Since fiber attachment is so constant a feature of chromosome structure this change is also suggestive, particularly in view of the variable taxonomic character of the groups of species involved.

The conclusion that these rearrangements in the relations of the chromatic substance found in the Acrididae may be indicative of a principle concerned generally with evolution or change in the chromosome complex is strengthened by observations that similar conditions obtain in the Locustidae. In the genus Jamaicana, Miss Woolsey finds the formation of multiples similar to those of Hesperotettix and Chorthippus, and earlier I had noted a multiple involving the accessory chromosomes in Anabus, similar to those in Hesperotettix and Mermiria. The relatively frequent involvement of the accessory chromosome in multiples may be an indication of change in its structure, because it is clear that it carries other determiners than those involved with sex differences. This element, because of its alternate passage from male to female, its differential rate of metabolism and union with certain euchromosomes is indeed admirably fitted to act as a means of promoting variations within the material basis of heredity.

In attempting a correlation between chromosomal conditions and the exhibition of body characters, it must be borne in mind that the differences, for instance, between the various saltatorial families of the Orthoptera, are not large, relatively. They pertain much more to relative degrees in development of a common series of parts than to the presence or absence of

unique structures. Our problem is then, not to find such additions or subtractions of chromatin substance as would account for the appearance or disappearance of distinctive bodily structures, but rather to note such changes in the hereditary mechanism as would explain proportionate increases or decreases in development of a like series of structural elements or characters. Part by part grasshoppers, locusts, or crickets are not so much unlike except in details of form, size, or proportion.

Indeed, considering the characteristics of the Acrididae as compared with those of the insect type in general the differences are not great. Function by function the activities of insects are performed surprisingly alike throughout the various Orders. Organs of perception of movement and of metabolism differ only in details of structure, not in fundamental character. It would be unreasonable to expect in the individual, therefore, any profound differences in the nature of the material substance controlling the development of the characters marking the group. Provided the ultimate units or genes were present in the germ cell, in their entirety, they might experience considerable variation in their form of integration without producing very marked somatic distinctions. It is not surprising, therefore, to find that rather marked differences in form, size, and behavior of chromosomes are only of generic significance.

Instances of distinct generic differences are not uncommon in the Acrididae and they concern many features of chromosome organization. Thus, in Mecostethus, all the chromosomes are of a slender rod shape and in the first spermatocyte lie extended in the equatorial plate without the formation of rings. Such a complex has not been found elsewhere among all the species studied. Chlœaltis exhibits a first spermatocyte complex in which the largest three pairs are united into multiples in the form of plain rings lying parallel to the spindle axis. Chorthippus shows a similar arrangement except that the rings are extended in part also within the plane of the equatorial plate. Hesperotettix viridis presents in different individuals a considerable variation in the union of chromosomes into multiples, and some of these conditions appear in other species of the genus. In Circotettix is found so permanent a union between two chromosomes that the normal number is apparently reduced by one. Accompanying this numerical difference there are shifts in the point of fiber attachment in many of the chromosomes so that they appear much different in shape.

Variations of this character are relatively of considerable magnitude and must indicate a measurable change in the nature of the ultimate chromatin units, and yet their effects, judged by taxonomic characters, are only of generic value. So far they are of undefinable significance in determining the general nature of chromatin changes that occur when organisms vary.

If, therefore, we lack understanding of the meaning of the strongly marked chromatin differences in a group of organisms so well worked relatively as the Acrididae, it would be of little profit to attempt appraisement of much less definite and marked variations in the chromosomes of widely removed groups of organisms. More than a thousand species of animals have now been studied, and it would seem that if there are significant evolutionary differences visible in the chromosomes they would have been detected. It was suggested by Meek that the diameters of the chromosomes increase in a definite way according to the evolutionary development of animal groups, but this was so patently incorrect that he was himself obliged to repudiate the suggestion. Attempts have been made to show that large chromosome numbers are characteristic of low development or specialization, but the criterion does not hold at all, for both small and large chromosome numbers are found in various groups of the most simple and of the most complex organization. Undoubtedly these differences in number are significant because they indicate variations in the grouping of the ultimate chromatin units, but, we lack as yet criteria for determining their meaning.

From these general studies upon chromosome numbers there have, however, appeared some facts of importance. They indicate, for instance, that even in groups with wide numerical ranges, there is a chromosome number of most frequent occurrence, and, in many cases, other numbers are multiples of this. Mrs. Harvey has called attention to the fact also that in groups showing marked affinities like the molluscs and annelids, the type numbers are the same. Although actual numbers may vary from one to a hundred, the range of these type numbers for Phyla is not great. Commonly the number does not exceed eighteen and generally falls below twelve. Every such evidence of uniformity in the integration of the chromatin speaks for unity in the form of chromosome organization and thus for continuity through phylogenetic history.

Important evidence of the relations existing between the chromosomes of different species within a group, where there is a range of chromosome numbers, is afforded by the studies of Metz upon species of Drosophila. Judging by relative size and the point of fiber attachment, he is able to show how two rod shaped chromosomes of one species are represented by a single V-shaped element in another.

If the complex of chromosomes were absolutely constant throughout a group of organisms, the determination of homologues and the tracing of relationships would, of course, be much easier. We are, however, not without explanations for such variations as do occur. Fusions of chromo-

somes lessen the type number; splittings, fragmentations, non-disjunctions, supernumeraries, and multiple complexes increase it. Fusions have been most often observed in germ cells and there the continuity of all the elements has definitely been determined. Increases by various means are noted most commonly in somatic cells, but, as Hance has shown, there is probably neither loss nor gain of the chromatin. The importance of all these observations lies in the convincing demonstration that numerical variations involve only rearrangements of the persistent chromatin aggregate.

Of much significance regarding the evolution of chromosome groups are the observations upon mutating and hybrid species. While it is true that most of these have been made on plants their general value is just as great, because the fundamental facts of chromosome structure and behavior are common to all organisms. It appears here that changes in chromosome number result in differences of body structure. An additional element even, as in Oenothera scintillans, produces a different plant structure. When the group is duplicated, as in Oenothera gigas, all the parts of the plant are increased in size. Similar chromosome modifications do not accompany the mutations in Drosophila, however, and it has been suggested that the marked cellular instability in Oenothera is due to a hybrid character. Cytological support is lent to this view by the resemblances to similar conditions in known hybrids. Numerous observations have shown that when species with different numbers are crossed, during the maturation process there occurs a pairing between certain of the chromosomes, while others, unable to find mates, are cast out into the cytoplasm and disappear. In other cases they may persist and be carried along, dividing in one maturation division. At each maturation period of the hybrid generation rearrangements take place until a condition of stability is reached. Then, even in the presence of the normal number of chromosomes, a different type of organism results because of the change in the composition of the chromosome complex. Studies upon cultivated plants show many instances of variations in chromosome numbers. Correlated with specific distinctions, Blackburn and Harrison found, for example, that in the genus Rosa the fundamental haploid number is seven and that there are certain species which are not only diploid but tetraploid, pentaploid and hexaploid. No forms with diploid complexes showed abnormalities in the maturation mitose, but in most tetraploid and in all higher multiple groups the number of chromosomes was reduced toward the type number. Similar results have been reached by Tahara in studies upon Chrysanthemum, by Kihara upon wheat and by Kuwada upon corn. Sakamura finds that in the one grained wheats the chromosome number is 14 and that the multipled

grained wheats show tetraploid and hexaploid groups. His suggestion that these represent an evolutionary series is in accordance with conclusions reached by other methods of reasoning.

From the knowledge now before us it would, therefore, appear that the relation between the chromosome mechanism and the development of the characters of the species in the individual is very direct, in fact is a causal one. It is also apparent that the constancy of organization of the ultimate chromatin units into chromosomes is variable in different groups. In some, as in the Acrididae, this is very definite and fixed throughout the family, in other cases, e.g., the Hemiptera, it is more variable. With sufficient evidence it would, however, appear that there is always a strong tendency for the establishment of a number of chromosomes typical of the group, even in so large a one as a Phylum. The persistence of individual chromosomes in a foreign cytoplasm, making possible the hybridization of species, offers a means for changes in chromosome numbers. To some extent this is due to a differential reaction of the individual chromosomes, some apparently being more resistant or adaptable than others. The crucial test of chromosome compatibility is the synaptic period in the germ cells. Up to this point they may function with apparent normality, but when the chromosomes of the two parents are brought into this intimate union they often fail to survive the ordeal and imperfect germ cells result. Crosses between species with different chromosome numbers have frequently been made, however, and it is then found that distinct chromosome numbers accompanying differential body characters result. The means for an evolutionary change on the chromosome complex is thus afforded. Indeed our experience would indicate that to establish any change in hereditary characters, there must first occur a modification in the chromosome complex, most commonly identified with a numerical alteration.

Available evidence would also indicate that the chromosomes are made up of smaller units, each of which is in some respect functionally different from others in that chromosome, and from corresponding units in other chromosomes. It is not clear whether this differential nature in each case is due to an entirely unique activity or whether it is the result of a variability in degree, rate or time of action. Logically, and in consonance with our experience, it would be more reasonable to regard the factors as having much in common, with individual differences in form, degree, or time of action. In view of the great numbers of cell divisions required to produce an organism, each of which results in a slightly different character in the total constitution of the individual, it must be true that the extent of activity of any one factor is not great, a very slight difference in its

operation each time being sufficient to produce an end result of larger value. Indeed it passes the range of human comprehension that there could exist a mechanism of such perfection as to have held a group like the Acrididae constant to type through such periods of time and through countless myriads of individuals. Differences in factors we must, therefore, assume to be of relatively minor nature.

It would seem, moreover, that as between morphological and physiological distinctions among factors, we must conceive such to be largely physiological. Structural differences there surely are, but these are unlike those characteristics of form which we have found in units of higher order. Cells are distinguished apart by varieties of form, symmetry, polarity, proportion of parts, etc., all related in some way to similar distinctions between tissues and organs. The chromosomes themselves display some of these differences of a spatial nature, but they seem to bear no relation to the parts of the body. While nerve cells and muscle cells are distinctly unlike morphologically and arrive at such a state by gradual differentiation, the chromosomes of their cells show no corresponding form changes. It is true also that there are most extensive physical differences in the same chromosomes of a cell, due to its activities.

Even more perhaps are distinctions between the ultimate chromatin units not those of what we call a morphological nature. For structural distinctions we should here, in all probability, have to seek those of a molecular character, and so would pass beyond criteria which we have employed in distinguishing between organisms and their parts. Physiologically, however, it is possible to conceive of the same sorts of reactions carried down to the ultimate chromatin units. All physiological activities are essentially physico-chemical in their nature and a certain part of the body is, e.g. marked by a high development of some one of these, like irritability, contractility, or secretion. The determining factor here is in the activity of the nucleus and probably in the preponderant function of certain of the chromatin units.

Taking all the available evidence into consideration, we must conclude that there is reasonable hope that we may be able to discover certain relations between the chromosomes of a group of organisms which will indicate to us their phylogeny. Very detailed studies, both cytological and genetical, should inform us of the specific nature of each chromosome. With sufficient of such group studies for comparison we may hope to reach some conclusions regarding the principles governing sub-division of functions between the members of a chromosome group. The test of homologues will largely be a functional one, structural differences serving as

guides to identification. Work so far accomplished, which can only be regarded as of the most preliminary character, is very encouraging and makes it reasonable to hope that not only will we arrive at a knowledge of the evolution of the chromosome complex itself but we will at the same time accomplish such an analysis of the constitution of one organism as to make clearer the relations which exist between different types.

ABERRATIONS IN CHROMOSOMAL MATERIALS[1]

CALVIN B. BRIDGES

Columbia University, New York City

In Drosophila melanogaster a considerable number of distinct somatic types have arisen that have been shown to be the result of particular aberrant groupings of chromosomes. For example, the mutant form "Diminished" is due to the loss of one member of the pair of fourth chromosomes (2n − IV). Also numerous aberrrations from the normal mode of inheritance have been traced to corresponding aberrations in the distribution of chromosomes or of sections of chromosomes. Most of our evidence as to the chromosomal conditions underlying these aberrations has been derived from genetical investigation, but the gentical finding has been successfully checked by microscopical examination in those cases in which the unit of change is a chromosome or the whole group of chromosomes (n).

The various types of chromosomal aberrations and their effects may be included under the general term mutations, and may be called sectional, chromosomal, or n-mutations, according to the unit of change. Sectional and chromosomal mutations may be called ratio mutations, since their effects are produced by changes in the ratio in which genes are present, the chromosome being regarded as aggregates of genes. But these genes are themselves different, and new differences are apparently arising sporadically by transformation of old genes into new. Since the various effects seen in the ratio and n-mutations are referable to the action of component genes, all these types of mutation afford light on the characteristics of genes, and on how they interact to produce a given result.

Analysis of the various mutational effects, and of the linkage relations, leads to the conception of a gene as a distinct chemical entity having a definite location in the chromosome. With each cell generation the original gene gives rise to two daughter genes identically located and (ordinarily) with the identical characteristics of the parental gene. In this increase in the amount of the substance of a particular gene, constituents that were

[1] Since this paper was read at the session of the Eugenics Congress it has been expanded and rearranged, and changed considerably in nomenclature. In making these changes other workers on Drosophila and on Datura have been consulted, but they are not committed to any of the terms used here.

present in the surrounding medium interact to produce a specific end product.

To account for the occurrence of a mutant gene, it is assumed that the production of the old type of genic material has ceased and in its place a new type of material is being produced continually. In this new type of synthesis the raw materials present in the surrounding medium are essentially the same as those present in the previous situation. This is clearly seen in the fact that the cell may carry on both types of synthesis simultaneously, as is the case in the heterozygote. The primary difference between the two types of synthesis to be sought then, not in the cytoplasm at large, but in the particular definite locus in which the synthesis occurs. Effective synthesis is thus seen to depend upon the action of some material situated at that particular locus; but when the synthesis has occurred the substance has not been used up, or else it has been reconstituted, for in the daughter loci the same reaction occurs at the succeeding growth period. This suggests that the reaction is catalytic, and specifically catalytic, since in the heterozygote one locus synthesizes one type of gene and the homologous locus synthesizes another. The situation can be accounted for on the assumption that the specific catalyst is the genic material itself; and this assumption is not out of harmony with the chemical conception of "autocatalysis." The reaction may be called autocatylytic if the genic material is both catalyst and an end product. The molecules of the gene are assumed to be such that if the proper raw materials are present in the surrounding medium interaction occurs and one of the reaction products is the initial type of genic material, which thus increases in amount.

The autocatalytic synthesis of a gene may be formulated: $G + C_G \rightarrow 2G + P_G$, in which C_G represents the raw materials taken from the medium in the synthesis of G, and P_G represents the series of end products that are returned to the cytoplasm. If, as seems most probable, the genes act also as heterocatalytic enzymes, other specific end-products of greater variety are synthesized. Considered from the standpoint of the end-products, genes are chemical factories each of which is synthesizing a characteristic set of products which are delivered to the common cytoplasm. The various products influence the constitution of the cytoplasm directly by their presence; they may interact with one another, as well as with materials from outside; and they may act as raw materials in the syntheses carried out by other genes.

The cessation of the synthesis of the old type of gene and the inception of the synthesis of a new form are accounted for by assuming that a chemical change has occurred in the genic material. ($G_0 \rightarrow G_1 \; . \; . \; . \; . \; G_1$).

The autocatalytic reaction $G_1 + C_{G1} \rightarrow 2G_1 + P_{G1}$ (together with whatever heterocatalytic action is present) liberates a set of end-products that is, or may be, different from that characteristic of the action of G_0, and accordingly the diversity of cytoplasm and of development in characters proceeds step by step with the diversity of genes by mutation. Such transforming genic mutation ("transgenation") is probably the most characteristic process in the production of mutant changes.

In producing development the genes of the entire complement act together, since all are liberating their chemical products into the common cytoplasm. But since the products of the different genes are different they take effect in different ways upon the developing organism. Thus some of the genes will have much effect upon one character but little effect upon another. Each character will be determined by all the genes, but in each case most of the effect will be produced by a much more limited number. Each particular character shows a grade of development corresponding to the number and effectiveness of the genes that are producing it. In the case of many of the characters there are genes tending to make the character less pronounced, and the grade realized is that corresponding to the equilibrium between these plus and minus modifiers. The directions of modification for each character are in general quite diverse, and it is somewhat for the sake of simplicity that they are lumped together as plus and minus modifiers. For example, the trident pattern on the thorax of Drosophila melanogaster may become darker or lighter in intensity, blacker or yellower in color, sharper or more diffuse, larger or smaller, and may change in shape by changes in any of its regions. While it seems probable from the facts of multiple allelomorphism that all the mutant forms of the genic material at a given locus have a like tendency, yet the situation is more complex, as the existence of specific and disproportionate modifiers shows. In genic mutation the point of equilibrium is shifted by the transformation of a modifier of one grade into a modifier of a different grade.

It is observed that the presence of an extra chromosome ($2n + 1$) or the loss of a chromosome ($2n - 1$) causes character changes in the individual possessing the abnormal group. Such character changes can be interpreted in terms of component genes as follows: Linkage experiments show that the various kinds of genes are distributed indiscriminately among the various chromosomes and along each chromosome. But since the number of each kind is limited, short sections of equal length would not ordinarily contain the same proportion of any one kind, and still less would they contain the same proportion of every kind. The loss of one of these sections (a condition known as "deficiency") might remove more plus than minus modifiers

(or vice versa), and since relatively more minus than plus modifiers would then remain in action, the grade of the corresponding characters would be shifted in the minus direction. This is the interpretation of the fact that a deficiency may cause many character changes, this complex of new characters being inherited as a simple dominant. In the case of the two dominant mutants Delta and Hairless, which show characteristics indicating that they are due to deficiencies, each presents a great variety of characters which are mainly opposite in direction in the two complexes. For example, the veins of Delta are heavy, and spread out at the marginal vein into deltas, while the viens of Hairless are delicate and vanish entirely at the margins. When these two types are crossed together the double mutant type is practically wild-type. The neutralization of these two dominants may be interpreted by supposing that Delta represents the deficiency of a set of minus modifires, that Hairless represents the deficiency of a corresponding set of plus modifiers, while the dihybrid has the original equilibrium restored. The gain of a section of chromosome (a condition called "duplication") would likewise lead to character changes through changes in the ratio of genes.

In a whole chromosome the ratios of plus to minus modifiers ought to be on chance closer to the ratios present in the whole complement, but on the other hand more kinds of characters might be involved, so that the character changes consequent upon the gain of a particular chromosome (through non-disjunction) might be both complex and extensive.

The loss of a chromosome seems to produce greater character changes than does the gain of that same chromosome. Thus in Drosophilia melanogaster individuals that have lost one of the pair of fourth chromosomes (2n − IV) through non-disjunction show many and extreme departures from the wild-type, while individuals that have gained a fourth chromosome (2n + IV) show slight differences from the wild-type. The differences that are present in the extra-IV individuals are the opposite of those present in the minus-IV's. Thus the minus-IV's have large roughish eyes, pale body-color, dark trident-pattern, short blunt wings, etc., while the plus-IV's have small smooth eyes, dark body-color, inconspicuous trident-pattern, long narrow wings, etc. This difference in sign between the characters of the plus- and the minus-IV's was expected on the basis of genic balance. From the genetical data it was evident that extra-IV individuals were present as half the flies in certain cultures, but they were not identified until a deliberate search was made for flies with characters the opposite of those already known for the minus-IV's. In Oenothera plus but not minus deviants from the 2n condition are known. In Datura all the possible

$2n + 1$ forms are known but none of the $2n-1$ forms have been found. These facts are interpeted to mean that the $2n-1$ forms are such extreme departures from the type that they are unable to survive.

If the loss of a chromosome produces greater character changes than the gain of the corresponding chromosome then deficiencies would be expected to cause greater changes than corresponding duplications. There is some evidence that this is true. In the case known as "Pale-translocation" the genetical data lead to the hypothesis that the end of one of the second chromosomes has been broken off and joined to the third chromosome. By outcrossing this type to normal flies it is found that flies possessing the extra section (2n + Pale-section) are viable and not greatly different in characters from normal. But the flies that lack this section (2n − Pale-section) are so changed as to be entirely unable to live. In all the cases in Drosophila to which the hypothesis of deficiency is applied the "homozygous deficients" (2n − 2 section) are lethal, while in two of the three cases in which duplication effects are present the "homozygous duplicants" (2n + 2 section) are viable.

If minus deviations tend to cause more extreme and more lethal character changes than do plus deviations, then deficiencies and the $n - 1$ gametes produced by non-disjunction should play a less direct rôle in evolution than do duplications and the $n + 1$ gametes. The plus deviations have the further possibility of being the basis for fresh diversity by transforming genic mutations. Presumably transgenation would go on independently in the (three or) four representatives of each of the genes of the unit involved. The identity and even the similarity of effect might be lost through large or successive transgenations.

It has been a paradox that forms triploid or tetraploid ($2n + n$; $2n + 2n$) are less inviable and less extreme in character changes than forms that are triploid for a single chromosome ($2n + 1$). In Drosophila melanogaster, for example, the triploid ($2n + n$) differs from the wild-type only in certain size features; but the plus-II's (2n + II) and the plus-III's (2n + III) are entirely unable to live, while the plus-X's (2n + X) live only rarely and weakly. The relative similarity in characters of the 3n and 4n forms to the 2n is understandable in terms of genic balance; for in these three forms the different genes are in identically the same ratios, while in the case of the $2n + 1$ and 2n forms many of the ratios should be different. The differences that are present in the 3n and 4n forms may be due in part to the changed physical relations arising from the greater nuclear content, and in part from changed chemical relations connected with critical concentrations.

The origin of 3n and 4n forms is traceable to a division of the chromosomes of a cell without division of the nucleus. This process is a kind of mass non-disjunction for which the term nuclear non-division (or simply non-division) may be convenient. Non-division, and indeed most of the mutational processes, may occur in the soma, giving rise to mosaics. Or they may arise early enough in development so as to involve both somatic and germinal tissue. This latter case should be especially frequent in plants. Self-fertilization following non-division, as in the case of a plant, would give rise to a tetraploid line; but in the case of animals, where cross-fertilization is the rule, the usual result of non-division would be triploid individuals.

Besides the mutational processes mentioned, there are several others, some of which are included in the classification of the table below. The primary classification of mutation is made on the basis of the unit of change, and the secondary is according to the kind of change that can affect each unit.

Mutation

UNIT	PROCESS	RESULT
Gene	Transgenation ($G_0 \rightarrow G_1 \cdots G_1$)	
Section	Deficiency	$n - 1$ section } gamete
	Duplication	$n + 1$ section } gamete
	Translocation	New linkage relation
	Inversion	New linkage relation
Chromosome	Non-disjunction	$n + 1, n - 1$ } gamete
	Elimination	$n - 1$ } gamete
	Compounding	$n \rightarrow n'$, where $n' < n$
	Fragmentation	$n - n'$, where $n' > n$
Group (n) nucleus	Nuclear non-division	2n } gametes
	Nuclear fusion	2n } gametes
	Binucleation	Mosaics
	Dispermy	Mosaics

VARIATIONS IN THE JIMSON WEED (DATURA STRAMONIUM) CAUSED BY DIFFERENCES IN THE NUMBER OF CHROMOSOMES

A. F. BLAKESLEE

Carnegie Institution of Washington, Cold Spring Harbor, New York

In normal (diploid) plants there are 12 pairs of chromosomes or a total of 24 in each vegetative cell.

If there is a single extra chromosome in a definite one of the 12 sets (making a total of 25), the plant shows specific peculiarities of structure. Thus, if the single extra chromosome is present in the chromosomal set which carries the determiners for the Mendelian characters purple or white flower color, the plant has, among other peculiarities, the arrangement of leaves which suggested the name Poinsettia for this mutant; if the single extra chromosome is in the set which carries the determiners for the presence or absence of spines on the capsules, the capsule is narrow suggesting the fruit of the Cocklebur for which the mutant has been named. An extra chromosome in a third set makes the plant a Globe mutant with globose capsules. Theoretically there are at least 12 "simple trisomic" mutants possible with 25 chromosomes, each having 3 chromosomes in one particular chromosomal set and 2 in all the remaining 11 sets.

The chromosomes contain factors or determiners for all the structures in the plant. One chromosomal set may contain determiners which tend to make the capsule long and narrow; another set may contain determiners which tend to make the capsule short and thick; and similarly for the leaves and other parts of the plant. The structure of the normal (diploid) plant is due to the resultant balance between the more or less opposing tendencies of the 12 chromosomal sets. In the simple trisomic mutants with a single extra chromosome in a specific set, the balance is disturbed and the determiners in this set have an increased influence upon the make up of the plant producing such mutants as Poinsettia, Cocklebur, and Globe.

Plants may have 1 extra chromosome in each of the 12 sets as in "Triploids" or 2 extra chromosomes in each set as in "Tetraploids," but in such plants the influence of the several sets is balanced and the plants are not greatly different in appearance from normals (diploids).

Table 1 gives the chromosomal types already observed.

TABLE 1

Chromosomal types of mutants in the Jimson Weed (Datura Stramonium). The somatic number of chromosomes is given in parentheses after each type.

- BALANCED TYPES (12n)
  - Diploids (Normal) (24)
  - Triploids (36)
  - Tetraploids (48)
- UNBALANCED TYPES (12n + x)
  - Modified Diploids (24 + x)
    - A. Simple Trisomic (24 + 1)
      1. Globe
      2. Poinsettia
      3. Cocklebur
      4. Ilex
      5. Mutilated
      6. Sugar loaf
      7. Rolled
      8. Reduced
      9. Buckling
      10. Glossy
      11. Microcarpic
      12. Spinach
    - B. Simple Tetrasomic (24 + 2, the 2 extras in the same set)
      1. Round-leaf Globe
    - C. Double Trisomic (24 + 2, one extra in each of 2 different sets)
      1. ex-Buckling (?) and a number of other double mutants not yet analyzed by breeding tests
  - Modified Tetraploids (48 + x)
    - A. Simple Pentasomic (48 + 1)
      1. Globe
      2. Poinsettia
      3. Cocklebur
      4. Ilex
      5. Rolled
      6. Reduced
      7. Glossy
      8. Microcarpic
    - B. Simple Hexasomic (48 + 2, the 2 extras in the same set)
      1. Globe
    - C. Simple Trisomic (48 − 1, a single deficiency in one set)

Simple trisomic mutants produce normals (diploids) and similar simple trisomic mutants in their offspring; diploid and tetraploid plants breed true, while triploids produce normals and the different trisomic mutants.

THE ATTRACTION BETWEEN HOMOLOGOUS CHROMOSOMES

JOHN BELLING

Carnegie Institution of Washington, Cold Spring Harbor, New York

My thesis is very simple. In two plants, Canna and Datura, a monocotyledon and a dicotyledon, homologous chromosomes, when more than two in number, are attached to one another before the first maturation division, in threes, fours, or fives.[1] Thus the attraction between homologous chromosomes, which is the foundation of their conjugation in pairs and of their random assortment, and so of Mendelian ratios and of linkage differences, may extend to five (or six) such chromosomes.

In place of cutting sections, pollen-mother-cells were squeezed from the anther into a mixture of 45 per cent acetic acid as fixative, ferric acetate as mordant, and carmine as stain. By varying the relative proportions, preparations could be obtained in which the chromosomes were nearly black, while the cytoplasm was unstained. After a day in the mixture the cytoplasm became plastic, and local pressure on the thin cover-glass broke the cell wall, allowing the contents to escape in a circular form while sufficient further pressure made the separate chromosomes assume a horizontal position. Among many such squeezes of single cells, some first prophases and second metaphases were found in which each chromosome or aggregation of chromosomes was horizontal and sufficiently apart from its neighbors. (The work on Datura was all done with the cultures of Dr. A. F. Blakeslee.)

In the normal Datura stramonium, the late first prophase shows 12 pairs of chromosomes, each chromosome usually transversely constricted, and each bivalent forming a ring, a V, or a bent or straight rod. Six size classes can be distinguished among the 12 bivalents (1 largest, 4 large, 3 medium, 2 small medium, 1 small, and 1 smallest). The second metaphase shows two plates of 12 chromosomes each, every chromosome being divided into two transversely constricted halves, so that it appears four-lobed. The six size classes can be made out in each plate. (In a hundred cases, there have been only one or two instances of an assortment of 13 to 11, or of 12 to 1 to 11.)

[1] This has lately been shown to be probab ly the case with six homologous chromosomes, also. (Note of October 28.)

In Daturas with 25 somatic chromosomes, the prophases show 11 bivalents like those of the normal plant; and also one trivalent, whose three chromosomes appear as a ring with attached rod, as a three-rayed aggregate, or as a bent rod. These three chromsomes are equal, and belong in different Daturas to different size classes. The second metaphase plates are usually 13 and 12, and in the plate with 13 an extra chromosome is found in one of the six size classes.

In Daturas with two different chromosomes duplicated, we find 10 bivalents in the prophase, along with two trivalents. The usual assortment is either 13 to 13, or 14 to 12, with about equal frequencies. The two extra chromosomes can sometimes be seen to belong to different size classes.

In the prophases of triploid Daturas there are 12 trivalents, or aggregations of three chromosomes each, these three chromosomes being of equal size. The six size classes can be readily distinguished. In the second metaphase the assortment may be seen to vary from 12 and 24 through all the intermediates to 18 and 18. The numbers accord fairly well with the binomial distribution expected if the trivalents are oriented at random on the spindle. In some buds there are many, and in others few cases of isolated chromosomes not included in either second metaphase plate.

In tetraploid Daturas the chromosomes are in fours in the prophase of the first division, forming quadrivalents or bigemini (Marchal). These appear usually as double rings, or as crosses. Usually two chromosomes of each quadrivalent go to each pole, but it is probable that sometimes three go to one pole and one to the other. The six size classes can be readily distinguished, and the four chromosomes of each quadrivalent are of the same size. The assortment is usually 24 to 24, there being two chromosomes of each kind in each metaphase plate; but not uncommonly 23 to 25 is found, or even 22 to 26.

In tetraploid Daturas with one extra chromosome, the assortment is usually 25 to 24, and in the second metaphase plate with 25 chromosomes there is one extra chromosome in one of the size classes. In the first prophase a quinquevalent of five chromosomes has been twice seen.

One tetraploid Datura with two extra chromosomes was examined. The common assortments were 25 to 25, and 26 to 24. In the second metaphase plate with 26 chromosomes, one of the size classes which usually shows here only two members in tetraploid plants occurred four times, while it was found twice in the corresponding 24-chromosome plate. Thus this chromosome occurred six times in the first prophase. (Two prophases of this plant have lately been examined, and each shows only 12 aggregates. It is probable that one of these is a sexivalent. Note of October 28.)

LINKAGE WITH LETHAL FACTORS THE SOLUTION OF THE OENOTHERA PROBLEM

GEORGE H. SHULL

Princeton University, Princeton, New Jersey

INTRODUCTION

There is perhaps no better way to open a paper on this subject than by quoting the following statement from Muller's paper on "An Oenothera-like case in Drosophila," which appeared in the Proceedings of the National Academy of Sciences for October, 1917:

> In Oenothera a form of the balanced lethal explanation was suggested by de Vries, only to account for his double reciprocal crosses, but it is evident from the analogy of the beaded case that it probably lies at the root of nearly all the unusual genetic phenomena of the genus. The two cases differ in detail, however, in that one or more of the lethals in Oenothera produce their effect upon the gametes, rather than upon the zygotes.

Beginning in 1913 and proceeding step by step I have been able to demonstrate the truth of Muller's statement to such an extent that the title of my paper seems fully justified by the data which have been secured. It will be impossible in the short time at my disposal here to do more than sketch the mechanism of heredity in the Oenotheras as it now stands clearly revealed, and to present samples of the evidence which has been secured.

In brief, the elements of the genetic machine which is operating in the Oenotheras, are as follows: There are seven pairs of chromosomes which, according to many careful cytological studies, are typically behaving during gametogenesis and fertilization just as do the chromosomes of other species of plants and animals. There is thus provided a mechanism capable of producing in Oenothera all of the genetical phenomena which are attributable to chromosome distributions in other organisms.[1] The "Oenothera

[1] I refer here only to the orderly succession of diploid and haploid generations, with the certainty that homologous maternal and paternal chromosomes are separated into different germ cells. In a recent note (Jour. Heredity **13**: 75, 76, 1922) Gates calls attention to the well known fact that the chromosomes in Oenothera "form a chain end-to-end like a string of sausages, and when they ultimately come to be side-by-side in diakinesis they are already in the short and stout condition in which twisting about each other is impossible." He thinks this fact must be "very disturbing" for those who write about crossing over in Oenothera. The empirical genetical evidence for crossing over

problem" may be formulated, then, in a sentence, thus: Why is it that with chromosomes visibly behaving as they do in other organisms, extensive and intensive breeding experiments covering nearly thirty-five years have led many able geneticists to the view that Oenothera is genetically "a law unto itself?" The answer to this question is as follows: With the exception of one character (the short style of brevistylis) all of the characteristics thus far investigated, by which the numerous Oenothera species are differentiated, are determined by factors located in a single pair of chromosomes, which I have designated "chromosome I," and the evolution of the genus Oenothera, in so far as it relates to these characters, reduces practically to the evolution of this single pair of chromosomes.[2] One of the first steps in this evolution was the origin of one or more recessive lethal factors, whose presence has acted like a mask behind which other genetic changes have taken place without being subjected to summary elimination in the struggle for existence. The evolutionary significance of the lethal factors appears to be not alone, however, that of a protection to other mutative changes, which Muller speaks of as chromosome degeneration; for a comparison of forms having the lethals, with corresponding forms which do not have them, indicates that the lethals may have had a *positive* rôle in the evolution of the group in addition to their passive rôle in protecting other factors from elimination. The alethal forms are usually inferior in vegetative vigor, or rapidity of development, or degree of fecundity, as compared with the lethal-bearing types, so that it seems probable that the lethals are either themselves stimulative in effect or else that they act as preservers of the stimulating effect arising from the interaction of the unlike factors

in the Oenotheras is unequivocal, however, as indicated in a preliminary way in this paper, and this evidence has been greatly strengthened and extended since this paper was written. It is only fair to point out in this connection, that genetical analysis of chromosome behaviors is vastly more refined and effective than can be attained by present cytological technique, so that if there is a real antagonism between the evidence from the two methods of investigation, the cytological studies are more likely than the genetical to be in error through not having yet attained their proper goal.

[2] O. Renner (Versuche über die gametische Konstitution der Önotheren. Zeitschr. indukt. Abstamm.- u. Vererb. 18: 121–294. 1917.) has given to a number of the gene-complexes which constitute the two members of chromosome I in various species, distinctive Latin names; but he understands by these names the genotype contained in the entire group of seven haploid chromosomes instead of the linkage-groups which constitute the single chromosomes of one pair, as they now appear to be (see op. cit., p. 229). Thus, the two gene-complexes which constitute the two members of this pair in Oenothera Lamarckiana are called "velans" and "gaudens"; the two in Oenothera biennis are "albicans" and "rubens"; the two in Oe. suaveolens are "albicans" and "flavens"; and the two in Oe. syrticola are "rigens" and "curvans."

(or the additive effect of dominant factors (Jones)) lying in the two members of chromosome I, which effect would seem to be analogous if not identical with the heterosis so frequently observed in the hybrids of other organisms.

The early origin of the lethals and their pronounced effect on the vigor and fecundity of their possessors account for their very general occurrence in the different species of Oenothera, and it is their general presence which has thus far limited the occurrence of those types of genetic phenomena with which we have become familiar in other organisms and whose relation to chromosome-behaviors has been fully established by a number of critical lines of evidence.

The lethal factors of Oenothera are of two kinds, the one kind destroying the zygote, the other either destroying one or the other class of gametes, or at least preventing them from functioning. It is the latter class of lethals—the gamete lethals—that are peculiarly characteristic of the Oenotheras, and which have been indicated as yet in only a few other plants and so far as I am aware have not yet been noted in any animal.

With this brief general statement of the conclusions to which my investigations have led me, we are now prepared to consider the nature of the evidence, which has been consistently presented, in repeated tests, often in a large number of matings, and for which there seems to be no other satisfactory interpretation than the one here given. I believe that, taken in the aggregate, these data amount to a demonstration.

It may be well to point out that, had the Drosophila breeders been confronted with the beaded-wings situation, not as an exceptional case which could be left on one side until a background of experimental evidence had accumulated from simpler situations which could be used with confidence as a basis of interpretation, but as the general type of nearly all Drosophila genetics, there would probably have been no more rapid progress in the unraveling of the Drosophila mysteries than there has been in the case of Oenothera.

Just as it was necessary in Drosophila to have the simpler situations worked out, in order later to be able to control the elements of a situation so complex as that of the beaded wings, so in the case of Oenothera, it has been needful first to find clear cases of linkage of factors without the confusing effect of lethals, before any confidence could be felt in an interpretation of the more involved cases in which the masking effects of lethals were present.

EXPERIMENTAL EVIDENCE

Linkage between rubricalyx buds and red stems

The first two cases which met this requirement came under observation in 1913, but were held with suspended judgment or even in a skeptical frame of mind until 1915 and 1916, respectively, when they were considered as clearly established cases of linkage in the sense in which we have become familiar with it in the Drosophila literature. Both of these linkages involved the rubricalyx pigmentation of the buds (R^h) in which the whole bud, except the ovary and the free tips of the calyx, are intensely reddened.

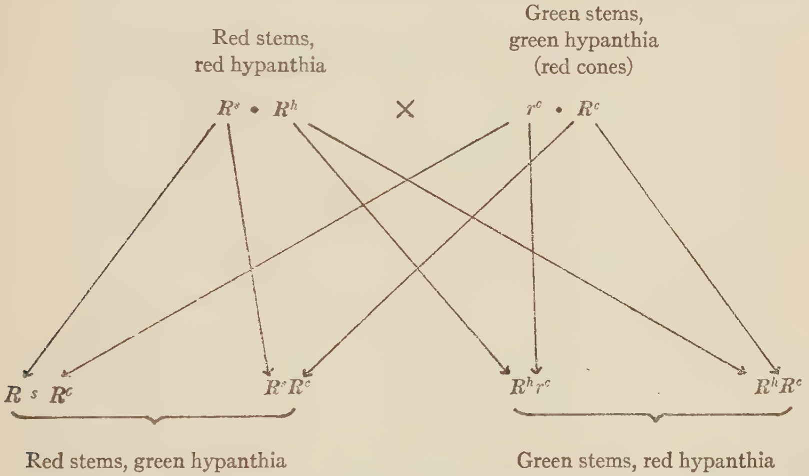


FIG. 1. Diagram showing the recombinations of the two chromosomes of pair I in a cross between red-stemmed rubricalyx and a form with green stems and green hypanthia like erythrina. The symbols in this diagram are to be understood as follows: R^h, a dominant factor for red hypanthium, i.e., rubricalyx; R^s, a dominant factor for intensely reddened stems; R^c, a factor for red bud-cones, associated with recessive green hypanthia; r^c, a recessive factor for wholly green buds.

The other two factors which were at this early date found to be linked with the factor for rubricalyx pigmentation were the factor *n* for the dwarf stature of nanella, and R^s which produces an intense reddening of the stems. The relation between red buds and red stems was such as to indicate that the corresponding factors, R^h and R^s, are allelomorphic to each other (or at least nearly so), for every plant tested, in which both red stems and rubricalyx buds were found, produced germ cells of two kinds only, with respect to these factors, namely, (a) those carrying the rubricalyx factor, R^h, and (b) those containing the red-stem factor, R^s. This discovery served

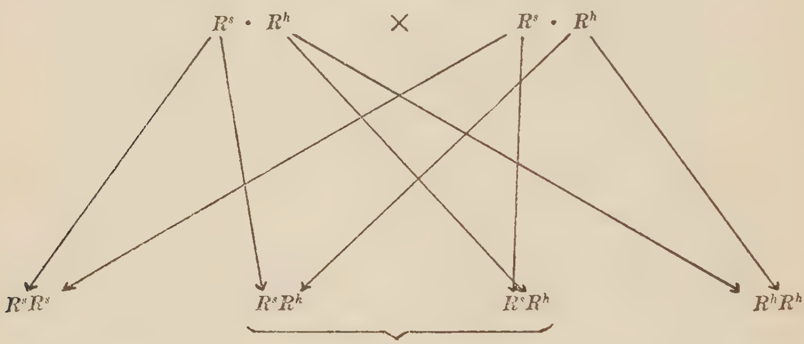
to clear up immediately the peculiar negative correlation which I had published in 1914, for with such a constitution, a cross between a red-stemmed rubricalyx (R^sR^h) and a green-stemmed plant with green hypanthia (r^cR^c) such as Lamarckiana or erythrina, gives a case of criss-cross inheritance of the type made familiar in cases of sex-linked inheritance.

This situation may be shown simply by a diagram, as in figure 1.

Self-fertilizing a plant of the red-stemmed rubricalyx type, R^s. R^h, results in a segregation of the Andalusian type, as shown diagrammatically in figure 2.

This is the situation described in my 1914 paper as a "peculiar negative correlation."

Red stems, red hypanthia × self



Dark red stems, green hypanthia | Bright red stems, red hypanthia | Green stems, red hypanthia

FIG. 2. Recombinations of the two chromosomes of pair I when a red-stemmed rubricalyx plant is self-fertilized. Symbols as in figure 1.

Ped. No. 1468, grown in 1915, was a small family showing approximately the expectation in this case, having 9 red-stemmed green-budded : 18 red-stemmed rubricalyx : 6 green-stemmed rubricalyx, and a larger family grown in 1916 (Ped. No. 1592) gave the same groups in the ratio 40:84:42. No red-stemmed rubricalyx has been tested which did not, when selfed, segregate in the manner indicated.[3]

[3] While Gates has repeatedly described his rubricalyx as having notably red stems, and I, too, have observed that its stems are more strongly reddened than those of rubrinervis or erythrina, its stems are still in what I call the green-stemmed group and in rather striking contrast to the intensely reddened stems produced by the factor, R^s. In the autumn the green-stemmed group often redden up to an extent which makes classification difficult.

Linkage between rubricalyx buds and nanella stature

The other original case of linkage, of which I was at first skeptical, but which was accepted as such in 1916, through the observation in that year that the one infrequent crossover class, rubricalyx nanella, was balanced by an equally infrequent occurrence of the corresponding crossover class, green-budded tall, was that between the rubricalyx factor, R^h, and the nanella factor, n.

As an example of the evidence of the linkage of these two factors, I may cite the data from three F_2 families from a cross between rubricalyx tall and green-budded dwarfs. These three families totaled 213 rubricalyx tall, 1 rubricalyx nanella, 3 green-budded tall, 50 green-budded nanella, instead of 156:52:52:17 which should have been approximated had the two factor pairs been independent instead of being closely linked.

A cross in which the two factors, R^h for rubricalyx pigmentation, and n for nanella stature, came in from the same side of the parentage instead of from opposite sides as in the foregoing example, gave a corresponding result, but with the two middle terms preponderating, as is expected in crosses of this type. Five F_2 plants (tall rubricalyx) from this cross, were back-crossed to green-budded nanella and gave in 1920 the ratio 22 rubricalyx tall : 244 pink-coned tall : 137 rubricalyx dwarfs : 11 pink-coned dwarfs. As the nanella plants are less easily reared than the talls there is some differential elimination of nanella plants, but as this seems to have affected about equally both the crossover class and the non-crossover class, the percentage of crossing over is not essentially modified. This back-cross test therefore suggests a crossover value between rubricalyx and nanella of about 9 units. The data are not yet adequate, however, to give this determination more than tentative value, as different tests have varied considerably in their indications as to the crossover percentage, though all agree qualitatively that the two factors in question are rather closely linked.

Linkage between pink-coned buds and nanella stature

The linkage between pink-coned buds and nanella stature is indicated by an F_2 ratio from four selfed F_1 plants, resulting from a cross between pink-coned tall and green-budded nanella. The F_2 of these four families consisted of a total of 206 tall with pink-coned buds, 20 tall with green buds, 11 nanella with pink cones, and 129 nanella with green buds.

Linkage between sulfur-colored flowers and red stems

In 1920 I had a large series of families representing a dihybrid combination between sulfurea flower color and red stems. Five of the families were

from selfed F_1 plants and 11 from crosses between sibs in the F_1 generation. These 16 families gave consistent results, and aggregated 1149 red-stemmed yellow, 61 red-stemmed sulfur, 77 green-stemmed yellow, and 686 green-stemmed sulfur. In this case I am tentatively assuming on the basis of other experiments that a lethal factor has cut down the class of red-stemmed yellows to about half their normal number and that the linkage value of s and R^s is probably about 26 units.

Linkage of revolute leaves with red stems and nanella stature

In the present season (1921) I have had several families which tested the linkage relation between a factor,[4] f, for the revolute-margined leaves of a mutant type which I call funifolia, and the red-stem factor, R^s,—also between revolute leaves and rubricalyx buds, R^h. The form with revolute leaves first appeared in my cultures (Ped. No. 1720) in 1918, as the result of a gene mutation which probably occurred in 1916. It had green stems and pink-coned buds. The funifolia segregates in F_2 have had in both the crosses mentioned above only the green stems and pink bud-cones of the original specimens of this type or the red-coned buds of an erythrina mutant of funifolia which was used in several of the crosses. Not a single case of crossing over between revolute leaves and bud color has been observed.[5] Thus, a cross between a green-budded, red-stemmed, flat-leaved dwarf (nanella) and a tall, green-stemmed, revolute-leaved funifolia, gave an F_1 of all red-coned, red-stemmed, flat-leaved, tall plants, and an F_2 by self-fertilization, consisting of only three types instead of the 16 which would have been present had the four known alternative characters been independently inherited. These three F_2 phenotypes were the two parental types and the F_1 type, the two former being presumably homozygous and the latter heterozygous, thus again presenting the Andalusian type. The lack of crossovers between f and R^c is probably due to the inadequate numbers of individuals in these tests.

Linkage of revolute leaves with rubricalyx buds

The F_2 from a cross between funifolia, which had long styles as in Lamarckiana, and a rubricalyx brevistylis, gave a similar result. In this cross both of the chosen parents had tall green stems, so that only three alterna-

[4] For description and figures of Oe. mut. funifolia, see Jour. Heredity **12**: 354–363. 1921.

[5] Crossovers have appeared in 1922, giving both rubricalyx-budded funifolia and red-stemmed funifolia.

tive characters were involved, namely, flat vs. revolute leaves, red vs. green hypanthia, and long vs. short styles.

The F_1 was uniformly flat-leaved, long-styled rubricalyx, giving on the basis of independent inheritance, an expectation of 8 phenotypes in F_2, but the F_2 consisted of only 4 phenotypes, instead of the 8 expected, the two new types being due to the independent assorting of the brevistylis character with either of the other parental combinations. All of the funifolia plants had red-coned buds with green hypanthia and all of the flat-leaved plants had rubricalyx buds,—intensely red on both cones and hypanthia. Brevistylis plants were found in approximately the expected Mendelian proportions in both the funifolia and the rubricalyx groups. This family, then, shows clearly the same relation between revolute leaves and rubricalyx buds, that the previously mentioned family demonstrated between revolute leaves and red stems. This is in full accord with expectation, in view of the fact that rubricalyx buds and red stems had been demonstrated to be allelomorphic to each other. If crossing over is possible between any two of these three factors it is certainly of very low frequency, and for the present it is held, tentatively, that the four factors for rubricalyx buds (R^h), red stems (R^s), red bud-cones (R^c) and green buds (r^c) form a system of quadruple allelomorphs, and that the factor for revolute leaves (f) occupies a nearby locus.

Having thus demonstrated that these five factors occupy the same (or very nearly the same) locus in chromosome I and that the factors for tall vs. nanella stature lie only a short distance from these, while the factors for yellow vs. sulfurea flowers are considerably more remote though still very obviously linked with them, let us turn to the characteristic lethals.

The characteristic zygote and gamete lethals

The existence of the gamete lethals was held tentatively as a working hypothesis for a number of years by Oenothera students in connection with the phenomenon of heterogametism which manifested itself in the production of unlike reciprocal hybrids. The presence of a pair of zygote lethals in Oenothera Lamarckiana also came to be strongly suspected because of the general occurrence of segregation in the F_1 generation of its crosses with other species and with many of its own derivatives. The difficulty, however, in demonstrating that Oe. Lamarckiana owed its peculiarity in this regard to the presence of lethal factors and that it was really a perpetual heterozygote in the Mendelian sense, lay in the fact that the F_1 phenotypes seemed to differ from one another in almost every

character instead of being differentiated from one another, as in the segregates of ordinary heterozygotes, by single characteristics. In fact, as I pointed out in 1914, the situation was so obscure that we could not at that time decide with any confidence, just what constituted a unit character in the Oenotheras. Two ideas, other than that of linkage with lethal factors, were favored by the complex nature of the segregates, namely, (a) the nuclear-chimera idea that chromosomes were hanging together in clusters, and (b) that there were so many non-compatible combinations of characters that only a small number, represented by the combinations which actually appeared, were capable of existence.

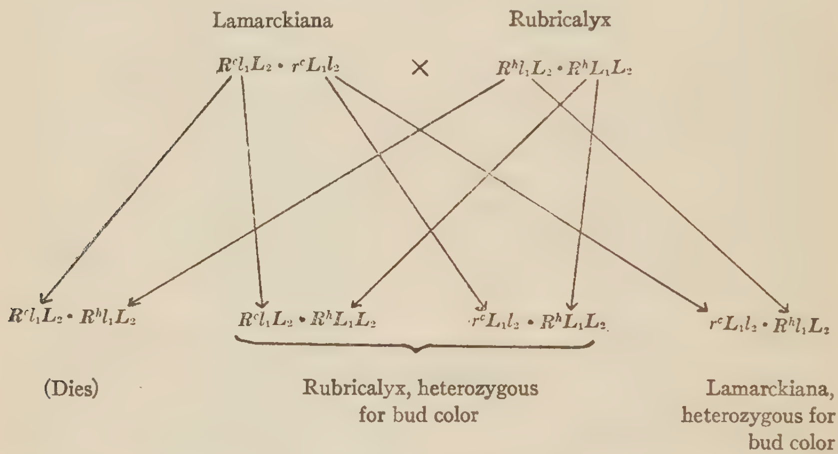


FIG. 3. Recombinations of chromosomes of pair I when Oenothera Lamarckiana with pink bud-cones and green hypanthia, is crossed with rubricalyx. Besides R^h, R^c, and r^c which have the same significance as given under figure 1, l_1 and l_2 are two recessive zygote lethals, and L_1 and L_2 are the dominant "normal" *vital* factors which are allelomorphic to these lethals.

Not until a known unit-factor could be followed through the genetic machinery was it possible to eliminate these seemingly plausible conceptions and establish in their place an interpretation which is in accord with the facts: (a) that cytological studies show no fundamental deviations in the chromosome mechanism, from that found in other organisms; and (b) that the numerous, very divergent species of Oenothera are quite generally fertile inter se, with only a moderate degree of sterility in the individual crosses.

The zygote lethals of Oenothera Lamarckiana

The demonstration that Oe. Lamarckiana is really heterozygous in the Mendelian sense was made in 1917, with the analysis of a cross between Lamarckiana and rubricalyx. In order to make the situation easily comprehensible, it is necessary to note that in Oe. Lamarckiana each member of chromosome I contains a recessive lethal factor, which we may designate l_1 and l_2, respectively, while in Oe. rubricalyx, as also in the corresponding forms, Oe. rubrinervis and Oe. erythrina, only one of the chromosomes contains a lethal, l_1 or l_2, while its mate has no zygote lethal. When a cross is made between Lamarckiana and homozygous rubricalyx, the F_1 progeny splits into the two types, Lamarckiana and rubricalyx, with respect to all characters except color of the buds, which are uniformly rubricalyx throughout both of the F_1 types, except that in the Lamarckiana group the pigmentation is usually a little less intense than in the rubricalyx group. This cross may be diagrammed as in figure 3.

From this diagram it is seen that the expected ratio between Lamarckiana and rubricalyx plants in the F_1 is 1:2. Leaving out of account three "mutant" forms in each of the two original reciprocal families from this cross (Ped. Nos. 1534 and 1535) the results secured in 1916 were:

(rubricalyx × Lamarckiana)	F_1	42 Lamarckiana	:	100 rubricalyx
(Lamarckiana × rubricalyx)	F_1	25 Lamarckiana	:	37 rubricalyx
	Total	67 Lamarckiana		137 rubricalyx
	Expected	68 Lamarckiana		136 rubricalyx

In the F_2, which was grown extensively in 1917, the rubricalyx type of F_2 plants gave splitting progenies in approximately the expected 2:1 ratio, 10 families aggregating 863 rubricalyx : 326 with green hypanthia. The deficiency in the latter group was probably due to the fact that the homozygous form is less vigorous than the heterozygous.

When the F_1 plants having the vegetative characters of Lamarckiana and the bud pigmentation of rubricalyx were selfed, they gave, in 9 families representing progenies of plants from both of the reciprocal matings, 396 plants having the form of Lamarckiana, or of several of its rare "mutations," *and every plant had rubricalyx buds.* In other words, although these plants had just been made heterozygous by the mating of gametes unlike with respect to the known factor for rubricalyx buds, there was no splitting out of the green-hypanthium character of the Lamarckiana grandparent.

That these same Lamarckiana plants, which bred true with respect to the rubricalyx buds, were actually heterozygous with respect to the factor,

R^h, was demonstrated at the same time by back-crossing to Lamarckiana with its usual type of pink-coned green-hypanthium buds. The resulting progenies from 10 such back-crossed individuals aggregated 347 rubricalyx and 349 pink-coned or green-budded, all of Lamarckiana form except a few of the so-called "mutants." This experiment at once established the correctness of the balanced-lethal hypothesis which had been up to that time held only tentatively as a working basis.

It is to be noted that these balanced lethals, l_1, and l_2, in Lamarckiana are zygote lethals. The microscopic evidence which is frequently cited in support of the balanced lethals, namely, that half the pollen and half the ovules fail to develop, would seem to be dealing with a wholly different set of lethals,—namely, gamete lethals. I know of no convincing evidence yet from genetic experiments that gamete lethals occur in Oe. Lamarckiana and its derivatives. The fact that the above-pictured results with the Lamarckiana-rubricalyx crosses gave the same ratios in the reciprocal matings bears against the existence of gamete lethals in chromosome I of this group. It is, of course, possible that gamete lethals occur in one of the other chromosomes, but in this case they can not distort the genetical results with respect to characters whose factors lie in chromosome I.

Demonstration of the gamete lethals

The existence of gamete lethals as factors lying at definite loci in chromosome I, has also been demonstrated in my cultures during the past two seasons, in two independent groups of material concerned with the problem of yellow vs. sulfur-colored flowers. De Vries has worked out the genetical behavior of this pair of alternative characters in both Oe. biennis[6] and Oe. suaveolens.[7] In both cases the color of the flowers in the hybrid families was typically that of the male parent. Thus $S \times Y = Y$ and $Y \times S = S$, and if the F_1 plants are selfed or back-crossed to the parent types, the F_2 progenies show no segregation, but again agree in flower color with the immediate male parent. This result is to be explained as follows: The wild types of both of these species carry a recessive factor, s, for sulfur-colored flowers in one member of chromosome-pair I, associated with a sperm-lethal, l_s, while the mate to this chromosome carries the corresponding dominant factor for yellow flower-color associated with an egg-lethal, l_e.

[6] De Vries, H., Gruppenweise Artbildung unter spezieller Berücksichtigung der Gattung Oenothera. viii + 365 pp. Gebr. Borntraeger: Berlin. 1913. See pp. 297, 298.

[7] De Vries, H., Mutations of Oenothera suaveolens Desf. Genetics 3: 1–26. 1918. See pp. 8, 9.

When such a plant produces eggs, the 50 per cent which receive the yellow factor, S, are prevented from functioning by the egg-lethal with which this factor is linked, and the sperms, correlatively, which carry the factor for sulfur-colored flowers, s, are prevented from functioning by the sperm-lethal linked with it. Thus it is that *functional* eggs carry only the factor for sulfur-colored flowers, while *functional* sperms have only the factor for yellow flower-color.

The demonstration of the correctness of this picture has come through the occurrence of repeated crossovers between the gamete lethals and the factors for flower color. It is found that the association between the factor for yellow flower color and the egg-lethal and that between the factor for sulfur color and the sperm-lethal can be exactly reversed, so that the egg-lethal goes with sulfur and the sperm-lethal with yellow, and it has also been demonstrated that in the absence of these lethals, typical 1:1 and 3:1 ratios occur with respect to flower color.

CONCLUSIONS

With the foregoing evidence before us that the known genetical phenomena in the Oenotheras are almost wholly attributable to elements lying in chromosome I, let us enumerate some of the conclusions which appear to be justified.

The F_1 splitting and unlike reciprocal hybrids which have constituted the most fundamental phases of the "Oenothera problem" are specifically accounted for by the demonstrated zygote and gamete lethals. The great advance which is made by my studies in regard to these is that they are shown to be *factors which occupy definite loci in a chromosome*, and that we can *appropriately* speak of *lethal factors*,—not merely "lethal gametes," "lethal combinations of chromosomes," or "lethal chromosomes."

A rational explanation is thus given for "heterogametism" and the so-called "mass-mutations" of Bartlett and Miss Cobb,[8] since a "single maternal or paternal chromosome" is substituted for "a distinctly maternal or distinctly paternal *set* of chromosomes." "Mass-mutations" are to be understood as the result of crossing over of recessive genes lying at considerable distance from the masking lethals. The term is hardly appropriate as applied by de Vries to the simple 2 : 1 segregations which take place when only one member of chromosome-pair I carries a zygote lethal, as in the case of rubrinervis, erythrina, rubricalyx, etc.

[8] Cobb, Frieda, and Bartlett, H. H. On Mendelian inheritance in crosses between mass-mutating and non-mass-mutating strains of Oenothera pratincola. Jour. Washington Acad. Sci. 9: 462–483. October 4, 1919. See p. 475.

We are now in position to classify the "mutations" of Oenothera under three heads: (a) gene mutations, (b) crossover mutations, and (c) anomozygous mutations (i.e., chromosome aberrations). It is not proper to discriminate among these, as some writers have done, by designating (b) and (c) "de Vriesian mutations," and (a) "Morgan's mutations;" such a distinction is not fair to either of the men mentioned, nor is it fair to history. It is not possible at this late date to eliminate the term "mutation" from the literature of Oenothera as a convenient term by which to designate genotypically distinct forms which appear with a frequency low enough to be in striking contrast with the larger categories which make up the bulk of any given progeny. Only genetical experiments can distinguish between (a) and (b), and cytological evidence is required in the case of (c).

The idea of "nuclear chimeras" is definitely set aside as unnecessary, and by the tracing of the major part of the sterility to definite lethal factors, Oenothera is made ineligible as an example of the phenomena depicted by Goodspeed and Clausen[9] under the name of a "reaction-system," though it does not, of course, prevent each Oenothera genotype from being, like a genotype in any other organism, an example of a harmoniously operating reaction-system.

All of the phenomena which have been attributed to a putative hybrid origin for Oe. Lamarckiana are accounted for, and although there is no ground for denying that Oe. Lamarckiana, like any other species, may have had a hybrid origin, there is no longer any reason to lay *stress* on this possibility, since *the genetical behavior of this species is shown to rest entirely upon its present factorial constitution.* There is absolutely no evidence that a lethal factor or any other genetic factor can be brought into existence as a result of hybridization.

The general compatibility of the various Oenothera species, notwithstanding their very striking divergences in character, is made easily comprehensible when it is considered that these divergences are limited in great measure to the divergent constitutions of a single chromosome pair, thus leaving 12 of the 14 chromosomes with probably essentially identical constitution throughout the entire group of Oenothera species which have yet been studied genetically.

Finally, the status of Oenothera as an object of research is materially improved, and the stone which has been rejected by certain of the builders is restored to its place as the "head of the corner," for Oenothera becomes at once the plant which has the largest number of known factors lying at

[9] Univ. of California Publ. 5^{11}: 301–322. Pls. 37–48. 1917.

definite loci in a single chromosome pair or linkage group; the number of distinct hereditary characteristics available within the genus Oenothera is apparently almost limitless; and new gene mutations are taking place with encouraging frequency. While the general mechanism of heredity in Oenothera now stands revealed in a fair degree of completeness, it can not be too strongly emphasized that the *details* are only *qualitatively* correct, and that a very great amount of work remains to be done in determining the exact *quantitative* relations of the known genes to each other, and in adding new loci to the map of chromosome I, as well as in discovering factors which may possibly exist in the other chromosomes. The door stands wide open, and many students must join hands in the colossal task of exploring the recesses which lie within, in order to bring to light quickly the genetical treasures which are certainly there.

A NEW TYPE OF VARIABILITY IN PLANTS

R. RUGGLES GATES

University of London (King's College)

The study of size-inheritance presents difficulties which do not appear with other forms of inheritance. These difficulties are chiefly due to (1) the absence of dominance, (2) obscuration of the results by the presence of fluctuations. The inheritance of nanism and gigantism is, however, fairly well understood. Many writers have explained size-inheritance where an intermediate F_1 generation is obtained and a wide range of sizes in F_2, as the result of the redistribution of several cumulative Mendelian factors for size. This conception has been applied particularly by East, Emerson, Hayes and others to the inheritance of such characters as length of cob in maize and length of corolla and size of leaf in tobacco. Certain recent facts make it necessary to re-examine more critically the whole matter of size-inheritance. It is possible that the inheritance of size in repeated parts such as flowers or leaves may follow a different law from the inheritance of, for example, size or weight of the whole organism in crosses between large and small varieties.

In crosses between large-flowered and small-flowered species of Oenothera, the F_1 is intermediate in flower size, while it is found that in the F_2 the mean flower size varies in different plants, also frequently in different flowers produced simultaneously on the same plant, and in some cases even the four petals of the same flower differ markedly in length. This segregation may be either continuous or discontinuous and is clearly non-Mendelian. In the F_3 and F_4 generations obtained by inbreeding the same behavior is observed, but with a decreasing range of variability. The curve of variability for a whole F_3 or F_4 population may superficially resemble an ordinary fluctuation curve, but it generally shows negative skewness.

When the curves for the petal length from individual plants are plotted they are found to be of many types, some of them showing two, three, four or more peaks, others a nearly continuous curve approaching the curve of fluctuation, etc. The element of inheritance resulting from the difference in size between the flowers of the parent species, the later somatic segregation on individual plants, and the absence of a normal fluctuation curve for most individuals, constitute this a new type variability. Considered as a

phenomenon of variability, it differs on the one hand from mutation and on the other from fluctuation. Considered as a phenomenon of inheritance, it is clearly not Mendelian owing to the irregular character of the segregation in the individual as well as between individuals. The condition has arisen through failure of adjustment between different size-tendencies inherited from the original cross between Oenothera biennis and Oe. rubricalyx.

Many related species and varieties of plants show conspicuous differences in size of flower. If intercrossing occurs in a population of such forms there will result a series of types giving a wide range of variaton in flower size. This would appear superficially to be due to fluctuation, but would in reality be a type of inheritance following crossing. Probably other cases of inheritance of petal size when analyzed in the same way as these Oenothera crosses, will be found to show similar non-Mendelian behavior. It is possible that the size of repeated parts in general will be found to follow the new law in crosses when experiments to determine this point have been made. In all such size crosses it will be important to determine the range and character of the variation in each individual.

Since Mendelian behavior appears clearly to be based upon the segregation of chromosome pairs in the reduction divisions, it appears probable that the phenomena of irregular variability and segregation in the individual as here described are based upon cytoplasmic differences, since there appears to be no definite distributing mechanism involved, and the time of segregation is not confined to the meiotic divisions.

THE ANALYSIS OF GENETIC DIFFERENCES THROUGH HAPLOID PARTHENOGENESIS

P. W. WHITING

The Iowa Child Welfare Research Station, The State University of Iowa

The parasitic wasp, Hadrobracon brevicornis (Wesmael), proves to be excellent material for genetic research on account of the ease with which it is manipulated, the large number of offspring produced from one female, and the brevity of its generation (ten days). The species is strictly arrenotokous, virgin females producing males only. Mated females produce both males and females, the latter arising in all cases from fertilized eggs. In addition to normal females, however, there are produced from fertilized eggs, gynandromorphs, mosaic males, and probably other abnormal individuals incapable of developing to maturity. While mated females may give a variety of progeny in peculiar non-Mendelian ratios, ovogenesis apparently follows orthodox lines and virgin females produce males from reduced eggs in normal gametic ratios.

Eye-color of the type is jet black. An orange-eyed mutant appeared in a fraternity of 253 males from a virgin female. When bred to black, orange proved to be completely recessive. Heterozygous females normally produce one to one ratio: but a lethal factor has been found showing linkage with the orange locus and killing the male pupae which possess it.

Defects in the fourth branch of the radius vein have been found in the progeny of wild females. These abnormalities have proved to be hereditary, but are very variable and much affected by environmental conditions. If the wasps are subjected to a rather high temperature during development, they are much more likely to show the defect than if temperature is low. Well fed large-sized specimens are much more likely to be defective than small starved individuals. In general, conditions tending to accelerate development produce more defectives, probably on account of a differential effect upon wing development as a whole and the development of this particular vein. There is also a considerable element of chance in growth, as is shown by the asymmetry of the defect, so that if environmental factors are constant there is still much variation within homozygous stocks. Humidity appears to be of little importance or none in affecting this character. Cultures are bred at 30°C. in order to reduce variation due to environment.

Defectives are separated into eight grades, the highest grade (8) denoting complete absence of the vein from either wing, the lowest grade (1) denoting a very slight break in the vein of one wing. Grade 4 denotes either the complete absence of the vein from one wing or its partial reduction in both. The frequencies for the different grades may be separated by periods, the first position denoting normals. Thus a fraternity of males from a virgin female graded,—395.0.2.0.1, there being 395 normal, two of grade 2 and one of grade 4.

Certain inbred stocks produce regularly less than 1 per cent defectives. These stocks are called low defective.

Another stock, called type, has produced 2507 normal males and 997 normal females, besides one defective male (grade 4). This male produced normal descendants only and was therefore a somatic variation, not a genetic mutation.

Another stock isolated and bred for a considerable time, produced 93 per cent defectives. Crosses were made with an orange-eyed stock having normal wings and the progeny continued in mass culture. Ten females, taken from this culture, produced 149 normal and 154 defective males besides a number of females. The mode of the defectives was grade 8. The female offspring fell into four classes: (1) Those giving all normals. (2) Those giving mostly normal but a few defectives. (3) Those giving normal and defective in equal ratio. (4) Those giving chiefly defective. A selection for higher defect was started from the fourth group and carried through eight generations. Although high grade defective parents were selected, there was no modification of the stock, either in ratio of defectives or in degree of defect. There were 92 per cent defective in the total series and 92 per cent in F_8. This selected series formed the basis of high defective stocks, both black- and orange-eyed.

An orange-eyed male of grade 8 (od8 ♂) from the high defective stock was crossed to a female from type stock. Type males and females resulted. Some of these daughters were isolated and produced type, defective, orange, and orange defective males. One of the last of grade 8 was crossed to a type female and daughters again isolated, producing males in ratio as before. This artificial alternation of generations may be expressed as follows:

Type stock

↓

→ od8 ♂ × + ♀ = + ♂♂ & ♀♀

↓

+ ♀ = only ♂♂, — +, d, o, & od

This process was carried to F_{20}, the odd-numbered generations, F_1, F_3, etc., representing the results of sexual crossing, while the even-numbered, F_2, F_4, etc., are the males resulting from parthenogenetic eggs and show segregation in gametic ratio. The odds, summarized, consist of black males,—517.1.0.0.4. and black females,—452.8.16.2.4. The five males with defective venation resulted in all probability from fertilized eggs and were sterile mosaics. Defectiveness in thirty females probably resulted from chance conditions of growth, temperature, etc., which reversed the dominance of the allelomorphs so that defective venation appeared instead of normal.

The evens, segregating generations, consist of black males,—899.7.45.40.85.51.112.132.178 or 899 normal and 650 defective; and orange males,—921.16.49.42.68.49.99.132.170. or 921 normal and 625 defective. This appears to be gametic ratio for two independently segregating factors with apparent deficiency of defectives due to somatic overlapping. There are in all 1820 normal to 1275 defective. On a one to one basis 272.5 of these somatic normals should be genetic defectives. Of the 1547.5 genetic defectives, 1275 show the defect or only 82+ per cent instead of the 92 per cent as in the selected defective series. Apparently something has been taken away that was present in the selected series. It is suggested that this may have been the factor for low grade defect, which, when added to the high defective factor, gives 92 per cent defective instead of 82 per cent or less which may be given by high defective alone. Although the number of individuals bred from single females was not large enough to calculate significant percentages, there was noticed between F_4 and F_8 a considerable decrease in wasps somatically defective in relation to those calculated as genetically defective. Both F_2 and F_4 give 87 per cent while the segregating generations from F_8 to F_{20} inclusive give 78+ per cent. The percentage of defectives given by the high defective factor alone may therefore be about 78 per cent. On the basis of independent segregation of factors for high and for low defective, one-fourth of the male offspring of heterozygous females resulting from the cross of high selected strain by type should have both high and low and 92 per cent of these should be defective, one-fourth should have high alone and 78 per cent of these should be defective, one-fourth should have low alone and 1 per cent of these should be defective, while the remaining quarter with neither defective factor should all be normal. The percentage of somatic defectives in the total should therefore be 42.45 per cent and if one-half of the normals be omitted as has been done in the above calculations, defectives make up 85.5 per cent of the remainder. This is not significantly different from the 87 per cent found in F_2 and F_4. F_6 consisted of numbers too small to be significant, but F_8 gave 78 per cent after which there was no further drop.

An orange male with normal wings was isolated from the first segregating generation (F_2) of this alternating series and crossed to type females. Daughters were isolated and their orange sons again crossed to type. This artificial alternation of sexual and parthenogenetic generations was continued to F_{14}. The segregating generations showed no high grade defectives. Seven of grade 2 and one of grade 3 appeared in F_2 and one of grade 4 appeared in F_6 after which the factor for low defective was apparently eliminated.

It is obvious from these as well as numerous other studies that, while a stock may be uniform genetically, it may show considerable fluctuating variability. Whether a genetic character difference from a chosen type appears in all of the individuals possessing the genetic potentiality of showing it, as is obvious for orange, or in a high percentage but not all, as has been practically demonstrated in the case of high defective, or even in less than 1 per cent, as may be the case with low defective, the factorial basis for the difference may be a simple Mendelian unit.

MUTATION

H. J. MULLER

University of Texas, Austin, Texas

Beneath the imposing building called "Heredity" there has been a dingy basement called "Mutation." Lately the searchlight of genetic analysis has thrown a flood of illumination into many of the dark recesses there, revealing some of them as ordinary rooms in no wise different from those upstairs, that merely need to have their blinds flung back, while others are seen to be subterranean passageways of quite a different type. In other words, the term mutation originally included a number of distinct phenomena, which, from a genetic point of view, have nothing in common with one another. They were classed together merely because they all involved the sudden appearance of a new genetic type. Some have been found to be special cases of Mendelian recombination, some to be due to abnormalities in the distribution of entire chromosomes, and others to consist in changes in the individual genes or hereditary units. It seems incumbent upon us, however, in the interests of scientific clarity, to agree to confine our use of term mutation to one coherent class of events. The usage most serviceable for our modern purpose would be to limit the meaning of the term to the cases of the third type—that is, to real changes in the gene. This would also be most in conformity with the spirit of the original usage, for even in the earlier days, mutations were conceived of as fundamental changes in the hereditary constitution, and there were never intentionally included among them cases merely involving redistribution of hereditary units—when these cases were recognizable as such. In accordance with these considerations, our new definition would be: "mutation is alteration of the gene." And "alteration," as here used, is of course understood to mean a change of a transmissible, or at least of a propagable, sort.

In thus trimming down the scope of our category of mutation we do not deprive it of the material of most fundamental evolutionary significance. For all changes due to the redistribution of individual genes or of groups of genes, into new combinations, proportions, or quantities, are obviously made possible only by the prior changes that make these genes differ from each other in the first place. It should in addition be noted that changes due merely to differences in the gross proportions of entire groups of genes

must be relatively incapable of that delicate adjustment which is required for evolutionary adaptation. And as to the question, frequently raised, whether all evolution is ultimately due to mutation, this is necessarily answered in the affirmative by our definitions of the gene and of mutation, which designate the gene as any unit of heredity, and mutation as any transmissible change occurring in the gene. The question of the basic mechanism of evolution thus becomes transferred to the problem of the character, frequency, and mode of occurrence of mutation, taken in this precise, yet comprehensive sense. And since eugenics is a special branch of evolutionary science it must be equally concerned with this problem.

In choosing the body of data wherewith to attack these questions of mutation, in their new form, it must unfortunately be recognized that the results with the evening primrose, Oenothera, although they formed the backbone of the earlier mutation theory, can no longer be regarded as having a direct bearing on the modern problem, since they cannot be shown to be due directly to changes in the genes. Certain of them, such as gigas, lata, scintillans, etc., have been proved by Geerts, Lutz, Gates, and others, to be due to abnormalities in the apportionment of the chromosomes. Very valuable information on the genetics of cases of this sort is now being obtained, especially in the work of Blakeslee, Belling, and Farnham on much clearer cases of similar character in the Jimson weed, and, finally, in work of Bridges on the fruit fly Drosophila. Most of the other so-called mutations in the evening primrose appear to be due to the normal hereditary processes of segregation and crossing over, working on a genetic constitution of a special type. Evidence for this was obtained in my analysis of the analogous case existing in the fly Drosophila, as follows. It had previously been shown by de Vries, and further elaborated by Renner, that germ cells or individuals of Oenothera bearing certain genes always died, in such a way that all the surviving individuals were heterozygous (hybrid) in regard to these genes. I later showed, through work on Drosophila, that when such a condition (there called "balanced lethal factors") exists, the situation tends to become still further complicated through the presence of other heterozygous genes, which are linked to those which cause death. When one or a group of these non-lethal genes crosses over (separates) from the lethals, as they occasionally do, they may become homozygous, producing a visible effect. Thus new types of individuals appear which may be ascribed to "mutation," whereas they are really due to crossing over. The work of Frost on stocks has shown that a precisely analogous situation exists in that form also, and G. H. Shull is obtaining direct evidence for the same conclusion in the evening primrose itself. In any event, it must be granted

that so long as this interpretation cannot be definitely refuted, these variations cannot be used as examples on which to base our theory of gene change. In place, then, of the elaborate system of conclusions which has derived its support chiefly from the results in the evening primrose, it will be necessary for our present theory of gene change to erect an independent structure, built upon an entirely new basis.

The data upon which the new theory must be built consist of two main sorts, which may be called direct and indirect. (1) In the cases giving the direct evidence, the occurrence of the gene change can be proved, and it is possible to exclude definitely all alternative explanations, such as contamination of the material, emergence of previously "latent" factors, non-disjunction, etc. So far, the only considerable body of such evidence is that gotten in the Drosophila work, where mutations have (in this sense) been actually observed in at least 100 loci. Considered collectively, however, there exist in other organisms enough scattered data to afford ample corroborative evidence for the generality of occurrence of mutations like those observed in the Drosophila work. In addition several specially mutable genes have been found in a number of plants (as well as in Drosophila) that are giving highly valuable information along their particular lines. And a number of selection experiments that have been performed on non-segregating lines of various organisms have also given us direct evidence, if not of the frequency, then at least of the infrequency, of mutations. (2) As for the indirect data, these may be gotten by examination of Mendelian factor-differences of all kinds, on the assumption that they must have arisen through mutation. Although this assumption can be shown to be fully justified, these cases cannot provide information concerning the manner of origin of the mutants, nor can they furnish a reliable index of the frequency of mutations, since the mutant genes may have been subjected to an unknown amount of selective elimination or selective propagation before the observations were taken. As for the still more indirect data, derived from studies of phylogenetic series and comparisons between different species, genera, etc., these occasionally give suggestive results, but where crosses cannot be made or where the differences cannot be traced down to the individual genes, such facts can seldom lead to trustworthy genetic conclusions.

On these various data, duly weighted, we may found our new mutation theory. We know nothing, as yet, about the mechanism of mutation, or about the nature of the gene—aside from the fact that nearly all genes hitherto studied behave like material particles existing in the chromosomes. Nevertheless there is always evidence for a number of empirical principles

regarding the changes of the genes, some of which may conveniently be listed here in the form of 14 statements. I shall have opportunity merely to present these principles, without attempting any adequate explanations of how they have been derived from the data.

1. The first and probably most important principle is that most genes—both mutant and "normal"—are exceedingly stable. Some idea of the degree of this stability may be obtained from some quantitative studies of mutation which Altenburg and I have made in the fruit fly Drosophila. It may be calculated from these experiments that a large proportion of the genes in Drosophila must have a stability which—at a minimum value—is comparable with that of radium atoms. Radium atoms, it may be recalled, have a so-called "mean life" of about two thousand years.

2. Certain genes are, however, vastly more mutable than others. For example, a gene causing variegation in corn, studied by Emerson, and another in the four-o'clock, studied by Maryatt, ordinarily have a mean life of only a few years; and that causing bar eye in Drosophila has a mean life of only about 65 years, as is shown by the results of Zeleny. (In expressing these results we are here using the physicists' index of stability, which seems most appropriate for the present purpose also.)

3. External agents do not ordinarily increase the mutability sufficiently (if at all) to cause an obvious "production" of mutation.

4. The changes are not exclusively of the character of losses; this is shown by the well established occurrence of reverse mutations, in bar-eyed and white-eyed Drosophila, in Blakeslee's dwarf Portulaca, Emerson's variegated corn, and probably in a number of other recorded instances. It is known that mutations having an effect similar to that of losses do occur, however, and they may be relatively frequent.

5. The change in a given gene is not in all cases in the same direction, and it does not even, in all cases, involve the same characters. The latter point is illustrated by a series of mutations which I am investigating in Drosophila, which all involve one gene, but which produce, as the case may be, either a shortened wing, an eruption on the thorax, a lethal effect, or any combination of these three.

6. The direction of mutation in a given gene is, however, preferential, occurring oftener in some directions than in others. This is well illustrated in the studies on variegated corn and four-o'clocks, and on the bar eye and white eye and other series in Drosophila.

7. The mutability and preferential direction may themselves become changed through mutation, as illustrated by some of the same cases.

8. The mutations do not ordinarily occur in two or more different genes at once. In only two instances in Drosophila have mutations been found in

two different, separated[1] genes in the same line of cells of one individual. But a recurrent case, apparently of this kind, has recently been described in oats, by Nillson-Ehle.

9. Not only does the mutation usually involve but one kind of gene—it usually involves but one gene of that kind in the cell. That is, the allelomorphs mutate independently of one another, just as totally different genes do. There is evidence for this derived from corn, Portulaca, and Drosophila.

10. Mutations are not limited in their time of occurrence to any particular period of the life history. This has been proved in the above mentioned studies on mutable plants, in Drosophila, and in other cases.

11. Genes normal to the species tend to have more dominance than the mutant genes arising from them. This is very markedly the case in Drosophila, where even the relatively few mutant genes that have been called dominant are very incompletely so, and might more justly be called recessive. In other organisms, the same condition of things is strongly suggested, although the direct data on occurrence of mutations is as yet too meagre to allow of certainty.

12. Most mutations are deleterious in their effects. This applies not only to the organism as a whole but also to the development of any particular part: the delicate mechanisms for producing characters are more likely to be upset than strengthened, so that mutations should more often result in apparent losses or retrogressions than in "progressive" changes. This is both an a priori expectation and a phenomenon generally observed.

13. Mutations with slight effects are probably more frequent than those with more marked effects. This must not be understood as referring to the different mutations of each given gene, but it applies in a comparison of the mutations occurring in different genes. Thus, there are more than a dozen mutations, in different loci, which reduce the size of the wing in Drosophila so slightly as to leave it more than half its original length, whereas only four reduce it to less than half-length. Mutant genes with effects so slight as to be visible only by the aid of specific co-genes seem to arise still more frequently. It is reasonable to conclude that the mutations with slighter effects would more often take part in evolution, because they should usually be less deleterious, and this conclusion is borne out by observations on the multiplicity with which such factor-differences with relatively slight effects are found in species crosses.

14. The range of those mutations which are of appropriate magnitude to be visible is probably very small, in comparison with the entire "spec-

[1] Contiguous genes may be affected in the rare cases known as "deficiencies," found by Bridges and Mohr.

trum" of mutations, so that there are many more lethals than visible mutations, and probably more subliminal than visible.

The above empirical and semi-empirical principles must be regarded as a mere preliminary scaffolding, for the erection of a later, more substantial, theory of mutation. Time does not permit me here to discuss which directions of research, and what methods, seem the most promising for future results. Suffice it to say that it is especially important to obtain accurate data concerning the effect of various conditions upon the rate of mutation. This seems one of the logical routes by which to work towards the artificial production of mutation and consequent more perfect control of evolution. At the same time such results should also give a further insight into the structures of the gene. The way is now open, for the first time, to such studies on mutation rate, first through the finding, by Emerson, Baur, Maryatt, Zeleny, and Blakeslee, of a number of specially mutable factors in different organisms, and second, through certain special genetic methods which I have elaborated in Drosophila, for the detection of lethal and other mutations there.

It has now become recognized that advances in theoretical or "pure" science eventually carry in their train changes in practice of the most far reaching nature—changes which are usually far more radical than those caused by progress in the applied science directly concerned. It may therefore be asked at this point by eugenists: "Are there any applications of the knowledge which has already been gained about mutation in general, to eugenics and to the principles which should govern us in guiding human reproduction?" I think that one such application is already clearly indicated.

In order to understand the nature of this application it will be necessary first to consider the proposition—emphasized by East and Jones in their book, "Inbreeding and Crossbreeding"—that the only way for a genetically sound stock to be formed is by its going through a course of inbreeding, with elimination, by natural or artificial selection, of the undesirable individuals that appear in the course of this inbreeding. The truth of this proposition depends upon the fact that many recessive genes of undesirable character are apt to exist in a population. Since the frequency with which these genes are able to produce their characteristic effects, i.e., to "come to light," depends on the closeness of the inbreeding, it is evident that inbreeding will be necessary in order to recognize the genes adequately, and hence to eliminate them.

Our present theory of mutation, however, carries us further than the proposition just considered. It shows that these undesirable genes have arisen by mutation; in fact, as stated in point 12, the *great majority* of muta-

tions are deleterious, probable even to the degree of being lethal, and it is also known, as noted in point 11, that many—probably the great majority—are recessive. In other words, our mutation theory shows that probably the majority of the mutations that are occurring are giving rise to genes of just the type specified in the above discussion. This immediately shows us that not only are inbreeding and selection desirable for raising the genetic level of a population, but they are absolutely necessary merely in order to maintain it at its present standard. For the same process of mutation which was responsible for the origination of these undesirable genes in the past must be producing them now, and will continue to produce them in the future. Therefore, without selection, or without the inbreeding that makes effective selection possible, these lethals and other undesirable genes will inevitably accumulate, until the germ plasm becomes so riddled through with defect that pure lines cannot be obtained, and progress through selection of desirable recessive traits can never more be effected, since each of them will have become tied up with a lethal. To avoid such a complete and permanent collapse of the evolutionary process, it is accordingly necessary for man or nature to resort to a periodically repeated, although not continuous, series of inbreedings and selections in the case of any biparental organism.

This conclusion is more than a mere speculation, or even a deduction from our principles. The reality of this process of mutational deterioration has been directly proved, in the case of Drosophila, through experiments that I have conducted on lines in which the processes that usually accompany inbreeding and selection were prevented: in these lines there was found an accumulation of lethal genes so rapid that it would have taken but a few decades to have brought about the presence of a lethal gene in practically every chromosome of every fly. Although the same general thesis undoubtedly applies also to mankind we do not yet know the speed of the process here. Its speed depends upon the actual frequency of mutations, which it will be very important—and extremely difficult—to determine in the case of mankind. Meanwhile, no matter what this rate may be, the process remains a real one, which must eventually be reckoned with, and either grappled in time, and conquered, or else yielded to.

I have dwelt at length upon this particular application to eugenics, of some of the mutation studies. I believe, however, that this is but one example of such applications, and that from an increasing knowledge of our theoretical science there will inevitably flow an increasingly adequate technique for coping with our refractory human material. Meanwhile, the crying need is for more of the theoretical knowledge—and for the support of pure science, in its investigation of the processes lying at the root of the germ plasm.

REVERSE MUTATIONS

CHARLES ZELENY

University of Illinois

The occurrence of reverse mutation is no longer questioned but cases of it are of importance because of their bearing on the general nature of mutations. The speaker has worked on the bar-eye allelomorphic series of Drosophila which has a number of valuable characteristics: (1) the details of the origin of its components are known, (2) the ommatidial counts give a quantitative evaluation, (3) the heterozygotes may be recognized and (4) the mutations are frequent enough to give an adequate measure of rate.

About 60 mutants were observed among 150,000 individuals.

Of the six possible shifts all except full to ultra-bar are on record.

Reverse mutations are more frequent than the original ones.

Recent origin is not an explanation of the difference in rate between reverse and original mutations. For instance, full derived from bar does not mutate more frequently than the original full.

The large jump from ultra-bar to full is as frequent as the smaller jumps from bar to full and ultra-bar to bar.

Direction of selection has no effect upon the rate or direction of mutations as observed in 42 generations of upward and of downward selection for eye-facet number.

Mutation outside of the bar locus may affect eye-facet number but there is no evidence that the presence or absence of such accessory mutations affects the rate or direction of mutation at the bar locus.

Direction of origin has no effect upon the direction or rate of mutation. For instance bar derived by upward mutation from ultra-bar differs in no respect from bar derived by downward mutation from full.

There is no evidence of periodicity in the mutations.

Mutations occur in the germ plasms of both males and females. This is indicated by the preponderance of females among the mutants, bar being a sex-linked character.

The mutations are not confined to a single period in the germ-cell history. Some of them at least come before the end of the gonial divisions because five of the forty-four cases valid for this purpose show mutant individuals appearing together.

The frequency of mutation at the bar locus is greater than in all observed accessory factors combined.

The different components of the bar series are definite entities comparable to definite chemical compounds or physical states. They do not grade into one another and their origin is not a factor in their behavior.

So far no environmental factor influencing rate of mutation in bar-eye has been discovered. There is no difference between stocks kept at 20° to 22°C. and those kept at 27°.

These results have an obvious bearing upon certain theories of evolution but there is not time to discuss them on the present occasion.

DARWINIAN EVOLUTION BY MUTATIONS

R. A. FISHER

Rothemsted Experimental Station, Harpenden, England

During the second half of the nineteenth century, the Darwinian theory of the gradual evolution of all living forms by the agency of Natural Selection, slowly won its way to acceptance, first by men of science, especially breeders and geologists, and finally by the whole body of educated opinion. It is not here the place to survey to the full extent of this revolution in human thought; it is enough that to thoughtful minds it dominated the outlook upon the history and destiny of the human race, and gave birth at the hands of Francis Galton to the Science, or rather the philosophy, of Eugenics. But, during the present century Darwin's views have been exposed to criticism in detail and in gross, from the two classes of students, the breeders and the palaeontologists by whom it was first most readily received. It is the purpose of the present note to examine very briefly the causes of this change of attitude, and to clear away certain misunderstandings, which spring chiefly from changes in the use of words, which have taken place during the past half century.

In the first place the discovery of Mendelism has made us familiar with the fact that obvious and easily distinguished differences in animals and plants are sometimes due to a single heritable factor, and some Mendelians have in consequence taken offence at the gradual and cumulative character which Darwin assigned to evolution. On the other hand certain palaeontologists to whom the gradual and progressive character of the evolution of fossil remains is becoming more and more evident, feel that we have here something which the geneticist cannot explain, and consequently fall back upon Lamarck's suggestion of the inheritance of acquired characters, or upon the mystic word "orthogenesis." Others again, impressed by the genetic constancy in pure line breeding, have somewhat rashly insisted that genuine mutations never occur. These different views, though proper to put forward for discussion among men of science, exert a bewildering effect upon the general public, who tend to lose their belief that science has anything to teach them about the history and the destiny of their race.

Of the facts unknown to Darwin and his contemporaries we have to take two into consideration. In the first place Mendelism shows not only that

obvious and easily distinguished differences may be due to single factors, but that the ordinary differences between parent and offspring, or between children of the same parentage, may be, and probably are for the most part, due to the segregation of Mendelian genes, and not, as Darwin seems to have thought, largely to new and arbitrary mutations of a heritable nature. What the older evolutionists took to be for the most part new heritable differences, the Mendelian interprets as, for the most part, old heritable differences, newly arranged according to the Mendelian system. In the second place pure line experiments have shown that in genetically pure strains, the appearance of entirely new genes is of relatively rare occurrence. It is not usually understood that these two new facts are logically connected: for, once the Mendelian view is accepted that genes do not blend, but segregate intact, it is clear that if in every generation new genes are introduced, the variability of the species will increase without limit. If the genes of the parents were to blend in the offspring, continual new mutations would be necessary to maintain the variability; but as under the Mendelian system of segregation there is no tendency for the variability to diminish, except in so far as by the gradual action of selection certain genes tend to disappear, we must not assume that in a state of nature, where the variability is approximately constant, new Mendelian alterations are introduced into the currency of the stock more rapidly than this gradual elimination takes place.

The fundamental facts upon which Darwin grounded his theory are more firmly established than ever: the universal tendency of animals and plants to breed up to the limits of subsistence has never been seriously questioned; the existence in wild and domesticated races of heritable differences has been consistently verified; the incidence of natural selection and the actual modification of types has been proved by many careful investigations. Nevertheless, owing to the changes which have taken place in the use of words, many would feel almost as though they were out of date if they styled themselves Darwinians. This change in terminology is principally due to the far reaching effects of the factorial system on our ideas of the constitution of living things. There is no need here to discuss the proper use of modern terms; for the purposes of the present note it will be sufficient to say that we shall speak of a species as differing in any Mendelian factor, when two or more allelomorphs of that factor are to be found in individuals of the species; that every individual of the species must belong, in respect of this factor, to one or other of the homozygous and heterozygous types formed by combining like or unlike allelomorphs; that the word *gene* will be used for the material basis of any allelomorph, and the word *locus* for the material

basis of a factor: so that we may speak of one gene supplanting another in the same locus as one allelomorph replaces another of the same factor. On the factorial system, then, an individual is specified if, for every factor concerned, we assign it to one or other of the homozygous and heterozygous types: in the simplest case, when the factor is dimorphic, there being only two homozygous and one heterozygous types. Any organ or trait of the individual will usually be influenced by many factors, so that the selection of any one trait will influence the proportions of the allelomorphs of all the factors which affect that trait. Since in nature many traits are, or more correctly the whole complex of traits is, subject to selection, natural selection within any species will necessarily be gradually increasing the proportions of some allelomorphs, and diminishing those of their alternatives, so that a gradual progress of the whole specific group must take place on the whole in the direction of improved adaptation to those needs which dominate selection.

The action of selection upon such a species will be exactly what the Darwinian would anticipate, with the theoretical reservation that in the absence of any mutations, progress must sooner or later stop; for the number of possible types formed by combining all the possible allelomorphs of all the factors present, though inconceivably great, is still finite. Of these types one is presumably the best adapted to the selecting environment, and when that type is attained improvement ceases. Of course the best possible combination of factors may not, when selection commences, exist in a population of many millions; thousands of generations of severe selection may be needed to bring it into existence, and establish it as the dominant type; it is true also that in the absence of new genes, the average value of any trait, such as human stature, might be changed to a value far outside the existing range of variation, merely by selection. Still it must be admitted that in the absence of mutation the variability of the selected species would be progressively diminished, and will finally vanish, so bringing evolutionary progress to an end.

But modern work, especially that of American workers on Drosophila, shows conclusively that mutations though infrequent do in fact occur; and it is worth while to observe exactly what bearing this fact has upon the Darwinian theory of evolution.

If we suppose then that a mutation has occurred, and an entirely new *gene* is present in a single individual of a population consisting of some thousands of millions, the history of its survival may be broadly divided into two periods. In the first period its survival or extinction is due mainly to chance, in the second period mainly to the general advantage or disadvan-

tage in the struggle for existence which the new allelomorph confers, on the average and in combination with the existing currency of genetic types, as compared with the alternative allelomorph, which it displaces.

In consideration of the first stage we may suppose that the chance of any *gene* of one individual appearing in 0, 1, 2, 3 . . . . individuals in the second generation, to be p_0, p_1, p_2, p_3, ... etc., such that

$$p_0 + p_1 + p_2 + \ldots\ldots = 1$$

These fractions will depend on the stage in the life history of the individual which we pick out for consideration: for the adult reproductive stage of many plants and animals, the series will be very similar to the Poisson series

$$e^{-1}\left(1, 1, \frac{1}{L_2}, \frac{1}{L_3}, \ldots\ldots\right)$$

If we construct a function

$$f(x) = p_0 + p_1 x + p_2 x^2 \ldots\ldots$$

then the chance of any one gene being represented in the second filial generation by 0, 1, 2, 3 . . . . individuals will be found by substituting $f(f(x))$ for $f(x)$.

This method enables us to compute the chance that the gene will not have become extinct in any number of generations; assuming the Poisson series, the chance of survival for n generations is nearly $\frac{2}{n}$; while *if it do survive* the average number of individuals affected will be $\frac{1}{2}n$, Thus roughly one mutation in 50 will survive 100 generations, and if so, it will on the average be represented in 50 individuals. These results are worked out for a population stationary in number.

Very disadvantageous genes, such as dominant lethals, will of course be cut off at once, but for those which are only of moderate advantage or disadvantage, the above may be taken to represent the first stage in survival, which is principally governed by chance. The second stage commences with the new gene established in a fairly large group of individuals, of varying genetic constitution, so that a fair number of new genetic combinations are being tested simultaneously. If those individuals which contain the new gene are found on the average of the chances of life, and on the average of the genetic natures with which it is combined, to be at a disadvantage in the struggle for existence, then the number of the mutant form will gradually diminish, with large fluctuations due to chance; in this way the disad-

vantageous gene will always be kept sufficiently rare to be in danger of extinction, and though the number bearing it may repeatedly be reduced very low without actual extinction, yet sooner or later fortune will fail it, and it will disappear from the race. On the other hand the gene which is found to confer a slight average benefit on the individuals bearing it, will tend to increase in numbers, somewhat more rapidly than its less favourable allelomorph. Even if the average advantage be only of the order of 1 per cent in a generation, it will gradually spread through the population. At first the fluctuations from year to year will be large; so that when 100 individuals are affected the average increase will be one in a generation with a standard deviation of 10. But when the number of affected individuals is larger the increase takes place with greater and greater regularity; for example a population of 1,000,000 will have an average increase of 10,000 with a standard deviation of 1000. At this point the spread of the favoured gene takes place with calculable regularity. Finally when nearly the whole population is affected its less favourable allelomorph becomes sufficiently rare for its survival or extinction to be at the caprice of fortune.

If we have rightly described the manner in which a new mutation is incorporated into the general stock of the hereditary qualities of a species, and the manner in which the variability of the species is maintained in spite of the occasional extinction of genes by selection, we are in a position to see how great an advantage it is to a species to have adopted methods of sexual reproduction on the Mendelian system. For mutation is necessarily a leap in the dark: the chances of failure are far greater than those of success, especially when the effect of the mutation is large. Hence there is a great deal to be gained if it be possible to maintain the variability of the species, with a minimum of mutations,—that is to say with the greatest stability of the reproductive processes. Now in a population differing in a great many Mendelian factors as all sexual populations are found in nature to do, a single mutation may enable thousands of new genetic combinations to be tested, and if any of these should happen to be very advantageous, it will by selection become the predominant type. It cannot be denied that many groups of animals and plants appear to carry on successfully by asexual methods of reproduction, but it is impossible to believe that these could adapt themselves so rapidly to slow changes of environment as is possible with sexually reproductive organisms.

THE FREQUENCY OF MUTATION AND THE INCIDENCE OF HEREDITARY TRAITS IN MAN

C. H. DANFORTH

Washington University School of Medicine, St. Louis, Missouri

In man, as in lower forms, pairs of somatic traits which show the Mendelian type of heredity have presumably come into existence as a result of mutation, one of the allelomorphic genes having been derived from the other, or both genes having arisen from the same source. The current conception of the gene as a discrete and more or less specific determining unit which is passed along through the germplasm of successive generations unchanged except for occasional mutations invests the question of the nature and frequency of such mutations with a fundamental importance. But while it has been possible for a number of investigators to secure rather precise evidence as to the frequency of several mutations in experimentally controlled material, data from human sources have thrown very little light on mutations in man. There are, however, some considerations which, if they do not lead to precise information, do at least serve to indicate the upper or lower limits for the frequency of certain mutations in the human germplasm. It is the purpose of this paper to present a brief discussion of some of these points.

The theory of the gene as generally understood implies the persistence of the same elements through successive generations, and the mathematical theory of probability leads to the expectation that *these elements will persist in the same relative proportions so long as no differential factors come into play.*[1]

The two factors which might change the proportions are selection and mutation. If the ratio between two alternative genes is known and the selection factor can be evaluated, a means is afforded for estimating the rate of mutation. This has been attempted with two classes of hereditary traits, in one of which the selection factor is presumably effective, but adversely, while in the other it is apparently negligible. By the term selection must be understood in this connection any influence whatsoever which may act on

[1] This matter has been discussed very fully by Jennings (Genetics 1: 53–89 and Genetics 2: 97–154), Wentworth and Remick (Genetics 1: 608–616) and Wright (Genetics 6: 111–123, 167–179).

either germplasm or soma in such a way as to affect differentially the rate of reproduction of two alternative types. Among such possible factors might be, for example, differences in the "survival value" of the two types, selective mating, linkage with favorable or unfavorable traits, or any other agency which might affect the two classes of individuals differently.

As representatives of traits which might be subject to selection that type of polydactyly which is characterized by a (frequently rudimentary) digit on the ulnar side of the hand or the lateral side of the foot, and the form of syndactyly in which the third and fourth digits of the hand or the second and third of the foot are united, were selected for consideration. These two traits are distinct and behave in heredity as dominants. They are frequently simulated by pathological conditions which are not hereditary or represent by-products of some other hereditary condition. There is evidence of one or more rather rare genes in the human germplasm which are capable of suppressing polydactyly in an individual where it might be expected to appear. Bonnevie[2] seems to have found such an instance. But a study of family histories makes it quite clear that the presence of this trait is due primarily to a single gene which is not dependent upon the coincident action of other genes (except those for which the species is homozygous) and which is only rarely entirely suppressed by other hereditary factors. A similar analysis of the data on syndactyly leads to similar conclusions in regard to the gene for that trait.

The present frequency of the genes for these traits can be determined only from the incidence of the traits themselves and the evidence on this point is rather unsatisfactory. According to records in the office of the Surgeon Genera lof the United States Army there were, among a certain ten thousand soldiers demobilized at Camp Dix, ten who showed syndactyly. In all of these cases the condition was confined to the feet. Those individuals in whom the syndactyly occurred also in the hands had doubtless been refused admission to the army. This would seem to indicate a higher incidence in the population as a whole, but the probable error is rather large and such data as it has been possible to collect from other sources indicates that the incidence of this trait can not be much greater than one in a thousand. A comparison of the frequency of cases recorded from the clinic indicates that the incidence of polydactyly is slightly, but only slightly, higher.

Since the traits are dominant and marriage between two similarly affected individuals is extremely rare, most cases indicate heterozygosis and the incidence of the genes is approximately one-half the incidence of their

[2] Bonnevie, Kristine. Polydaktyli i norske bygdeslegter. Norsk Mag. f. Lagen., 1919, pp. 1–32 (known to the writer only through reviews).

respective traits. With matings strictly at random the precise ratio between a gene and its allelomorph could be determined if the exact incidence of the trait were known, for it has been frequently pointed out that if under such conditions the ratio between two allelomorphic genes is as a:b the proportion of the different classes of individuals is as a^2 homozygous for one condition, to 2ab heterozygous, to b^2 homozygous for the alternative condition. In the present instance $(a^2 + 2ab):(a^2 + 2ab + b^2)::1:1000$, from which the values of a and b may easily be deduced. Determined either way it appears that in the germplasm of the whole population there is about one gene for syndactyly to every two thousand genes for the allelomorphic normal condition.

A matter of especial interest at this point is the fact that both polydactyly and syndactyly occur in widely different racial stocks and have also been reported in different species of anthropoid apes, not to mention still lower forms. In view of the great diversity of conditions under which present races and species exist it is difficult to believe that the appearance of these traits is anything new and the conclusion is justified that they have recurred in different lines during immense periods of time, perhaps antedating the origin of many existing species. If either of these traits had any positive value in increasing the ultimate fertility of its possessors one might expect that it would long since have become common to the whole species. Before proceeding beyond this point, however, it is desirable to inquire just what should be expected of a trait which has a positive selection value.

For the purpose of such an analysis it may be assumed that at a given time the ratio between the number of genes representing a dominant trait and the number representing the normal allelomorphic condition is as a to b. Then if individuals possessing the trait were to mate always with normal individuals, the number showing the trait would be in the proportion of a heterozygotes to $\frac{b-a}{2}$ normal recessives. The subsequent matings will be a between heterozygous and normal individuals and $\frac{\frac{b-a}{2}-a}{2} = \frac{b-3a}{4}$ between normal individuals. If m be taken to represent the average number of offspring for each mating, the first group will produce $\frac{ma}{2}$ heterozygous and $\frac{ma}{2}$ homozygous offspring, while the second group will produce $\frac{m(b-3a)}{4}$, all homozygous and normal. The ratio between the number

of offspring that carry the trait and those that do not is $\frac{ma}{2} : \frac{m(b-3a)}{4} + \frac{ma}{2} = 2\,ma : m(b-3a) + 2\,ma = 2a : (b-a)$. In the absence of selection this ratio would represent the relative proportion of heterozygous to normal individuals in the second and succeeding generation, but if the traits have a different survival value, then a certain proportion, s, of 2a and a different proportion, t, of (b−a) will survive and the ratio of children born in the second generation will be altered to 2sa: t(b−a). If heterozygous individuals were always to mate only with normals this relation would assume the general form $\frac{2\,s^n a}{t^n(b-a)}$, where n is the number of generations considered. When the mutation confers any advantage, s is greater than t and the formula represents the minimum possible rate of increase for the incidence of the trait, since it provides that through heterozygosis a maximum number of recessive normal genes shall profit by the favorable selection occasioned by the effect of the dominant genes with which they are associated. This formula applies up to the time when heterozygous individuals become sufficiently numerous to occasionally mate with each other. If individuals showing the trait were always to mate with each other a condition approaching homozygsis would obtain and the ratio of mutant to normal individuals would be as $\frac{as^n}{2} : \frac{bt^n}{2}$ or simply $\frac{as^n}{bt^n}$. This formula represents the maximum possible rate of increase. With random mating the true value of the ratio, of course, lies between these two extremes. But when, as is usually the case, a is very small and b is very large the value of the two fractions is almost identical until the ratio of numerator to denominator reaches about 1:10. It will be apparent, from the nature of the matings it presupposes, that the value of $\frac{2\,s^n a}{t^n(b-a)}$ can never exceed ½.

Two steps serve to reduce these formulae to more practical form. First by converting s:t into such form that t is equal to 1, t^n may be eliminated from the denominator. Second, what is really desired is to know how many generations will be required to raise, by selection, the incidence from $\frac{a}{b}$ to $\frac{a'}{b'}$. The second formula developed above represents the relative incidence both of mutant to normal individuals and of mutant to normal genes, the first formula represents the ratio between heterozygous and normal individuals. Converting the first formula into a formula for the ratio of

mutant to normal genes we have 2 as^n mutant genes to 2 $(b-a) + 2\,as^n$ normal genes $= as^n : (b-a) + as^n$. Putting $\frac{as^n}{(b-a) + as^n} = \frac{a'}{b'}$, we have $b'\,as^n = a'\,(b-a) + a'\,as^n$ or $b'\,as^n - a'\,as^n = a'\,(b-a)$, whence $s^n = \frac{a'\,(b-a)}{a\,(b'-a')}$. In the second formula $s^n = \frac{a'b}{b'a}$. The values of all the terms in these equations are known, or assumed, except the value for n (number of generations) and this value is represented by

$$n = \frac{\log.\left[\frac{a'\,(b-a)}{a\,(b'-a')}\right]}{\log.\,s.}\ \text{in the one case and}$$

$$n = \frac{\log.\left[\frac{a'\,b}{a\,b'}\right]}{\log.\,s.}\ \text{in the other case.}$$

In other words, if the ratio of two genes is as a:b and the one gene confers upon its possessor qualities such as to give an advantage over the alternative condition that may be represented as s:1, the number of generations required to raise the original incidence from $\frac{a}{b}$ to $\frac{a'}{b'}$ will be somewhere between the values represented by these two formulae. As stated above so long as $\frac{a'}{b'}$ is not greater than $\frac{1}{10}$, the difference between the two values amounts to almost nothing. Fortunately in all ordinary circumstances this requirement is met and either formula alone is serviceable.

It is not known what the incidence of polydactyly or syndactyly may have been in any past epoch but the formulae developed above show that had any dominant trait had an incidence of one in a million and had it conferred in the long run an advantage one one-hundredth greater than the advantage conferred by the recessive normal condition it would have taken only about 925 generations for the trait to acquire a frequency ten times as great as the present frequency of syndactyly. As indicated above there is evidence that both syndactyly and polydactyly have been in existence for a period many times greater than that indicated by this number of generations, from which it may be inferred that neither of these traits has had any positive selective value. The possession of these traits has been either a matter of indifference or, in the long run, a positive detriment to the lines in which they occurred. In the former case the present incidence of the genes for these traits represents the accumulated mutations which have occurred during the past history of the race and there would seem to be no escape from the conclusion that since earliest times one line of genes in

approximately every two thousand has undergone mutation from the normal to the syndactyly producing form. The number of lines that have mutated to the polydactyly producing form is apparently slightly greater. Since the time when the first mutation occurred is unknown this throws no light on the *rate* of mutation beyond indicating that it must have been extremely low.

If the trait is actually unfavorable in its net effect, the rate of mutation must be such as to bring the incidence to its present value and to balance the adverse effect of selection. In a population numerically about stationary the average number of generations through which a dominant trait persists among any descendants of a person showing the trait gives a measure of the selective value of the trait. Letting n represent the average number of generations through which a trait persists in a family and $\frac{a}{b}$ the incidence of the trait in the population at large it follows that the frequency of mutations necessary to maintain that incidence will be $\frac{a}{bn}$. There is a rather common belief, and possibly some inconclusive evidence, that both polydactyly and syndactyly represent, or are in some way associated with unfavorable factors, but an examination of a considerable body of data makes it seem highly improbable that the average duration of these traits within the families where they occur is less than three generations even when correction is made for the rapid increase in our population. With $n = 3$ and $a:b = 1:2000$ the frequency of mutation is indicated on an average of one gene in six thousand. Mutations from the normal to the syndactyl condition can hardly be more frequent than this unless it be that the condition is actually increasing or that when the mutation does appear it persists, on the average, for less than three generations. If, as is quite possible, syndactyly has an average duration of more than three generations the frequency of mutation must be correspondingly less. The data for polydactyly, as indicated above, are essentially similar.

It may be recalled that there is a considerable number of dominant traits which are probably slightly unfavorable and which have an incidence not greatly different from that of syndactyly. The incidence of these traits is no doubt maintained in part by recurring mutations. The frequency of such mutations could be estimated if the average number of generations through which they persist were known, but it is very doubtful if the maximum frequency is often greater than 1:6000. In some of these there is evidence that the average duration is for only a very few generations, and in such cases the maximum frequences of mutations can not be much below this value.

The second class of traits mentioned at the beginning, those in which the selection factor is apparently negligible, admits of a slightly different treatment. The traits selected from this group as types are (1) suppression of the palmaris longus muscle, apparently a dominant trait,[3] and (2) complete absence of hair from the middle of segments of the digits, a recessive trait.[4] Both of these traits occur in various races of man and in occasional anthropoid apes. A similar analysis to that employed in the case of syndactyly shows that neither of these traits has any appreciable value in increasing the differential productivity of its possessors. On the other hand there is not the slightest indication that they are in any way disadvantageous, and, being so obscure that they can be detected only by careful examination, the possibility of sexual selection is also eliminated.

For purposes of analysis the data on the muscle furnish much the better material. Fortunately absence of this muscle has been studied extensively in the anatomical laboratories of various countries with the result that extensive and reliable data are available. The manifestation of the trait is somewhat influenced by sex, being less affected in females, which consequently furnish better material for genetic study. In this sex the trait is manifest (i.e., the muscle is absent on one or both sides), according to published reports, in 14.7 per cent of bodies dissected at Petrograd and in 21.9 per cent of bodies dissected at Paris. In Alsace the percentage is about the same as in Paris. If the trait is dominant and the reported frequencies are approximately correct, the incidence of the gene for suppression of the muscle must be about 10:115 in the population from which the Russian dissection material was drawn, and about 16:115 in the population from which French material came. In the American negroes the incidence of the gene is not over 5 in 115.

Since there is no positive selective value associated with the trait the difference in the incidences for these three groups must be attributed to differences in the number of mutations that have occurred. If the existing races of Europe were differentiated from a common Asiatic stock toward the close of the early Paleolithic period, and other races of men separated somewhat earlier in this period,[5] the present European races are separated from their common ancestor by some 50,000 years and from the common ancestor of all races by perhaps three times that period. Allowing an average of four generations to the century this represents respectively about 2000 and 6000 generations. Attributing the different incidence in the

[3] Thompson, Batts and Danforth: Amer. Jour. Phys. Anthropol. 4: 205–218, 1921.

[4] Danforth: Amer. Jour. Phys. Anthropol., 4: 189–204, 1921.

[5] Osborn: Men of the Old Stone Age.

different races to differences in the number of mutations that have occurred and assuming that the race with the smaller incidence represents approximately the incidence of the parental stock the difference between two groups is an index of the minimum number of mutations that has occurred since the two stocks separated.

Comparing the incidence of the gene in the negro and the Russian germplasm it appears that for every 115 normal genes there are about 5 more mutant genes in the latter than in the former. If 6000 generations represents anywhere nearly the time since these two groups, along with others, diverged from a common ancestor, these additional mutant genes must have been acquired in this length of time. If, as is probably the case, the negro has been producing occasional mutations during this period, the Russian germplasm must have produced slightly more than the number indicated. These figures indicate that in the course of 6000 generations at least 5 in every 115 gene lines which have persisted, underwent mutation in this one direction. Since there is no evidence of selection, this may be presumed to be the rate of mutation in this particular germplasm, from which it follows that there has been, on an average, one mutation in every generation for each 138,000 genes. If, as some might be inclined to think, the two germplasms have passed through more than 6000 generations since they separated, the rate of mutation has been less than this.

The white races represented in Europe are more closely related and the approximate time of their divergence may be estimated with greater assurance. It is doubtful if these races have during the past 50,000 years reproduced at an average rate much in excess of four generations to the century, in which case 2000 generations may be assumed to be close to the maximum time since the separation of the west Russian from the French and west German stocks. At the present time there is a difference between these stocks of 6 mutant genes to every 115 normal genes. Correcting for the rate of mutation in the Russian germplasm as determined above there has been in the more highly mutating "French" stock during this period 22 mutations for every 345 lines that have contributed to the present population. This gives an average for each generation of one mutation to every 31,364 genes. This represents the minimum rate, but there is no reason apparent for thinking that the mutations could have been much more frequent than this. In our own population where the incidence of the trait is slightly higher than in France there must be with our present birth rate, an average of one of two cases each year in which the trait appears *de novo*.

In the case of complete absence of hair from the middle segments of the digits there are much less extensive data. In white Americans in general

the ratio of the gene for this trait to that for its normal allelomorph is about 1:1, while the American negro is almost homozygous for it. These facts are not sufficient to warrant an attempt to compute the rate of mutation, but it may be pointed out that in this case, unlike the preceding, the rate has been much higher in the negro than in the white race.

In conclusion: It has been shown that when certain conditions are met a basis is afforded for estimating the approximate rate of mutations in man. Some mutations occur repeatedly, but the frequency of such occurrences differs in different racial stocks. Moreover a race which shows a relatively low incidence for one type of mutation may show a relatively high incidence for another type. These facts indicate a parallelism, but not an identity, in the general tendencies of different human germplasms.

A SIMPLE EXPLANATION OF THE HEREDITARY MECHANISM

LOUIS LEGRAND

Tunis, Africa

For half a century most biologists have tried to visualize heredity by the means of special representative particles which, hypothetically, were endowed with all the qualities needed by their theory. It is possible, however, with a minimum of creations of the mind, to obtain a satisfactory idea of the hereditary mechanism, by the use of some very simple constructions, without any need of special particles and without leaving the ground of observed facts.

It is first necessary to admit plainly the distinction between the *fixed* and immutable characters and the *not fixed* and changeable ones, and this distinction remains true for the two realms of Nature.

From the characters which can define individuals and which are constantly transmitted, we must separate the characters which are never seen to change in animals of the same species: For example four limbs and hair for mammals; retractile nails for a carnivore; a single occipital condyle and feathers for a bird. Such characters are the basis of our classifications; they are subject to the laws of correlation and are as much immutable as they are interesting. Some most important parts of the body of an animal, teeth, for example are of this type, which is very often used in the classifications.

Fixed characters are at least specific characters, and even still more comprehensive, being also characters of genus, of order, of class, of branch.

Other characters, which vary from an animal to another of the same species, and from one generation to the following one, ought to be called "unfixed characters," and are to be ranged as follows:

1. Sex and secondary sexual characters.

2. Characters of race and variety: for example in the human species, the color of the skin, of the hair, of the iris, the pigmentation of epidermal cells, the form of hair on section, the cephalic, nasal and maxillary indexes, constituting the facial physiognomony of each race; the average stature and span; psychic aptitudes of each race; all these characters are always transmitted when parents are of the same race.

In the third group, linked with the preceding by insensible shades, we find some superficial, sporadic and less important characters, which are not regularly transmitted; they stand in the neighborhood of teratology and pathology, such as hemophilia, baldness, albinism, familial deafness, daltonism, hereditary optic neuritis; some diathesis compatible with fecundity; the coarseness or thinness of face, of hand or foot; musical or mathematical aptitudes,— all these are atavic or ancestral characters.

The last group also includes the quite indefinite variety of characters suitable to immediate parents; their transmission sometimes is very precise, sometimes not recognizable; their type is like naevi, like some very slight details of body, of sensorial apparatus, of skin; like the quality of arterial, muscular, glandular tissues; the most part of diathesis and all the scale of tempers; some psychoses and neuroses; longevity; some qualities and sensorial deficiencies, such as short-sightedness. Such heredity can be found to hold even to histological details, as for example the familiar resemblance of palmar veinous arcades, and chiefly these dispositions of the papillae of the finger's pulp, so often used for anthropometric test.

Fixed characters are evidently hugely more important than unfixed ones. It is surely an insignificant thing which causes a horse to become white or black, swift or bulky, fit for race or for carriage, it is, on the other side, something important which causes the same horse to become a vertebrate, a quadrupede, an herbivorous, a solipede.

If such a discrimination between fixed and unfixed characters is admitted, we have now to confront it with the constitution and histologic description of genital cells. In other words, it is necessary that some concrete and distinct elements, corresponding to each genus of characters, should be found in that plasmatic mass which is described at the beginning of each life, that is to say the fertilized egg.

Let us then consider a fertilized egg, already separated from the mother, in order to abstract all maternal plasmatic supply: such an egg, by definition, if kept in a convenient place, will be fit for segmentation, that is to say to develop these fixed and unfixed characters according to their reciprocal importance and to synthesize them into the well known specific forms.

The schematized fertilized egg, in whatsoever living type we consider, appears like a globular mass of cytoplasm of maternal origin, including two half nuclei, one of maternal, the other of paternal origin. As the cytoplasmic mass is greater than and surrounding these nuclei, we are logically led to believe that cytoplasm is the material support of fixed characters, which characters are common to both sexes and also predominant in the features of every living being. By exclusion, these two half nuclei, of comparatively

such reduced size, will correspond to unfixed characters, which are, or may be different in each of the parents.

So it is no question here of using some strange or scarce histological peculiarity; we only rely upon what is universal and known for a long time, namely, these three distinct elements at the origin of each ontogenesis. One is common to both sexes and is this large mass of plasmas (or characters) fixed together during all the life of species and of individuals. This is temporarily fused with two small masses of plasmas (or characters), unfixed during the life of species, but fixed henceforth during the individual life. It is to be believed that such a disposition is the result of some physiological division of labor between both sexes, as ancient in phylogeny as is the appearance of the Metazoa.

We must now try to analyze further this schematic explanation of the egg, and realize the mechanical relations by which unfixed plasmas ought to be ruled. The same gradation which has been admitted in the way of fixation of characters can be found again in the respective spaces occupied by their representative plasmas, in the egg ready for segmentation. In other words, *unfixed* plasmas will then be nearer to the position of the definitely *fixed* ones (that is to say to the surrounding cytoplasm) since they will represent some the more anciently and some the more recently fixed characters. Consequently unfixed plasmas (characters) of the *racial* type, for example, ought to be placed nearer to the fixed (and specific) plasmas (characters) and to be more adhesive to them than are the ancestral or *individual* plasmas (or characters).

But on the other hand, living types are found (like Cyclops, Crepidula), where not only in the original egg and blastomeres, but even in some of the adult cells, paternal and maternal chromosomes remain distinct. Since, however, this singular, and yet unexplained fact of the longitudinal division of chromosomes at the beginning of each synapsis can be construed as a temporary separation of the maternal and paternal chromatin (or of these synthetic plasmas which represent and perpetuate them during the ontogenesis), we are led to conceive that a fertilized egg has the constitution shown in figure 1, where the reciprocal importance of each plasma is shown in relation to the formation of corresponding characters.

But we must visualize these plasmas, with their probable constitution, which consists of elastic and malleable substance, flattened by reciprocal pressure. They ought then to be disposed towards each other, according to a definite order: so that the plasmas from each parent being of the same dynamic value and power, ought to accommodate themselves with those of the opposite side, just as the scales of a vegetable bulb are analyzed in layers.

Thus figure 2 where the composite nucleus alone is shown, is more in accordance with facts than is the first one (fig. 1).

With such a conception of hereditary substance by imbricated plasmatic "leaves," of unequal value in transmitting various characters, we may consider what will be the result of their reciprocal coincidence and mobility.

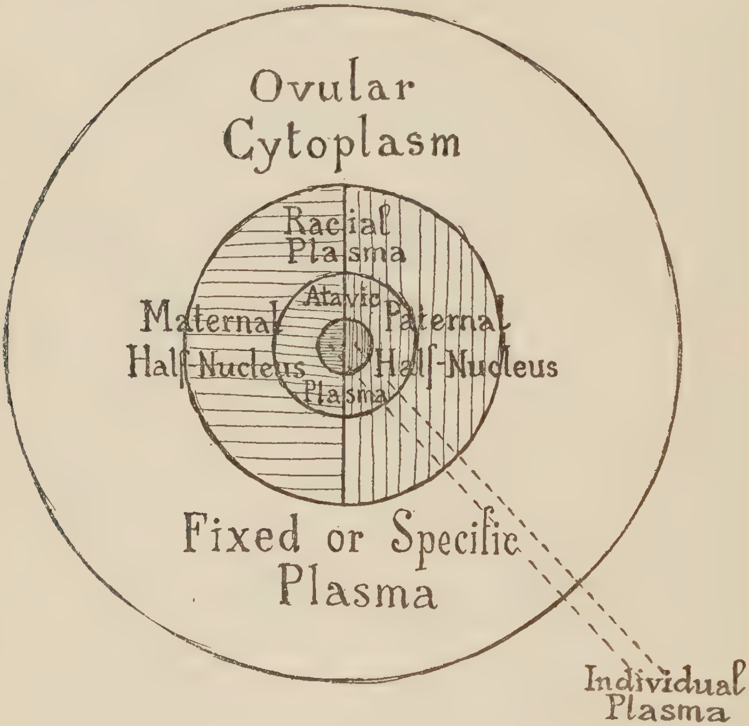


Fig. 1

Schema of the whole Fertilized Egg

Leaving for a moment these compulsory positions of each unfixed plasma, we believe that the possible reciprocal positions of these plasmatic planes are quite indefinite before amphimixis is accomplished. Just after the amphimixis shock is over, however, these plasmatic layers after hesitating

for a moment are definitely fixed together, and remain so through all the subsequent karyokinesis during the life of the individual.

The curves DC, DE, JE, JA (fig. 2), for example, are susceptible of indefinite variation, as the contact points D, F, H, G, are able to move both sidewise and forward or back. If this first design of plasmatic planes is exactly transmitted to blastomeres and to all the following cells of the body, as long as it is growing, there will be at our disposal a mechanical explanation of the slightest and finest hereditary transmissions throughout all the cellular generations in which ontogenesis is summed up, and we can understand that each unfixed character is able to maintain its individuality up to the end of individual growth.

By this scheme, too, we avoid the problem of the transmission of fixed characters, because the corresponding plasmas are superabundantly supplied either by their continuity with the surrounding maternal ones, or by exterior autotropic digestive synthesis.

If an explanation of latent characters is wanted, it is sufficient to admit that above all, the main point in order for a character to become manifested, in the figure as in reality, is not the mass of the plasmas present, but how much the surfaces of contact are stretched. This is then the degree of fixation, of each of these plasmatic blocks, to their surrounding *fixed* plasmas.

Consequently, only the zone which in the egg as well as in each cell, both unites and separates the two types of plasmas, is living and active. This zone of contact, of reciprocal sticking and fixation between cytoplasm and nucleus or nuclei can be called *the zone of manifested characters.* On the diagrammatic figure of the egg's nucleus (fig. 2) this zone is indicated by the successive lines HA, AB, BC, CH; that is to say these plasmas, which the chance changes of amphimixis have brought to some central points like K, K′, K″, will have no hereditary action: They are not to be manifested as characters. Plasmas are not latent, but those characters which are dependent on them, *are* latent.

Thus at the origin of each individual, some very important parts of their plasmas, which are effectively transmitted, have not, however, the least value in morphogenesis, because they are not affected by the zone of fixation.

So can be solved the celebrated antinomy of a parent transmitting to his progeny some characters which he does not himself show while not transmitting many of his own characters.

Unfixed Plasmas and Characters.

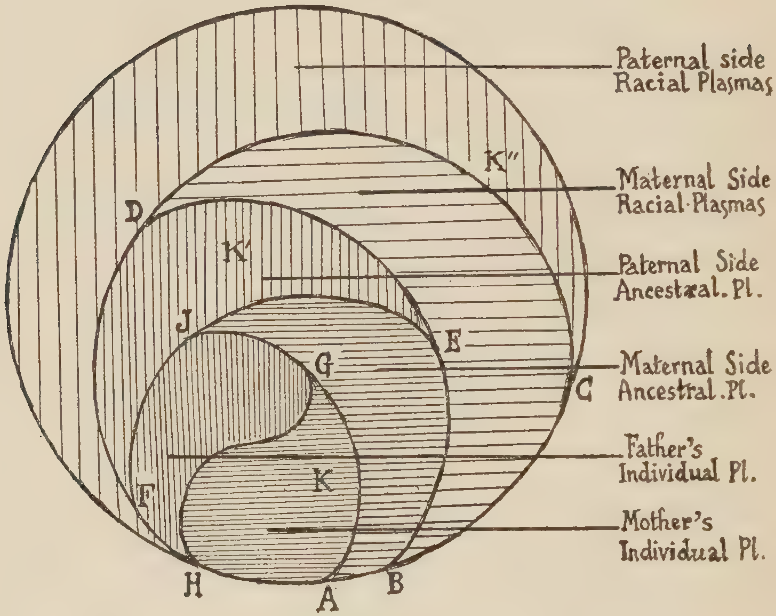


Fig. 2

Plasmatic Constitution of a Fertifized Egg's Nucleus.

DOMINANT CHARACTERS

These figures still afford an explanation why some types of unfixed characters are more likely to appear than are others: For example, the most frequent to appear are the racial ones, represented by the great surface HC + BC, and are evidently strengthened if both parents are born of the

same race. It explains too, why some parental or maternal characters are dominant. This is for the same reason as that given above, namely, if their plasmas are flattening some portion of the manifestation zone, they are able to exclude, to eclipse those of the opposite sex: these eclipsed plasmas becoming unable to express themselves from the dynamic point of view, are called recessive.

The fertilized egg (fig. 2) shows the preponderance of the paternal racial characters, since CH is greater than CB; the exclusive appearance of some ancestral characters from the maternal lineage in AB, the corresponding paternal block being totally driven back inside the spheroid and therefore remaining eclipsed and recessive. Finally, such an egg nucleus shows also some imperceptible contact of parental characters (from paternal lineage), in H, and another, narrow zone of maternal origin, from H to A.

The various phases of karyokinesis must be considered, by hypothesis, as tending to reproduce, in every new-born cell, the same plasmatic type. We can therefore conceive the repercussion of this type upon all organs and apparatus of the adult body and the automatic unrolling of resemblances proportionally with growth. All the body's features depend on the way by which amphimixic chromatine combined. If the angle of meeting was slightly different, the whole form of the body would be consequently influenced and another hereditary type would be built. The geometrical combinations of such lines and planes are quite innumerable, and we have to consider, not an explanation for *all* characters, but only for the unfixed ones, or more precisely, these morphologic modifications which the presence of these unfixed characters impress upon the total development of the *fixed* ones.

In fact, the problem of heredity is greatly simplified, provided that our distinction between both plasmas and characters holds. Then, indeed the transmission of fixed characters and plasmas is an evident fact of material continuity, at each generation, by the nutritive reserves of the egg or the maternal blood. Their continuation during life is determined and assured by digestive assimilation, which rigorously and continually affords adequate supply of the fixed plasma's material.

These figures also may be used to explain the oldest, the most expressive of unfixed characters, sex. This governs all other unfixed characters and impresses something of its own nature. As it appears like some transition between both types, it ought to be inserted in the plasmatic relationships, between the big sphere of *fixed* plasmas and the nucleus of *unfixed* ones. It is then sufficient to admit, that, at the very moment of the amphimixic joining, when these curved planes are being accommodated to each other,

sex is determined. This follows because the totality of one sex's plasmas, when added together, must necessarily eclipse and exclude those of the opposite sex.

In other words, the sex which, in the total amount of the fixation surfaces of its representative plasmas in the specific sphere, has the greatest

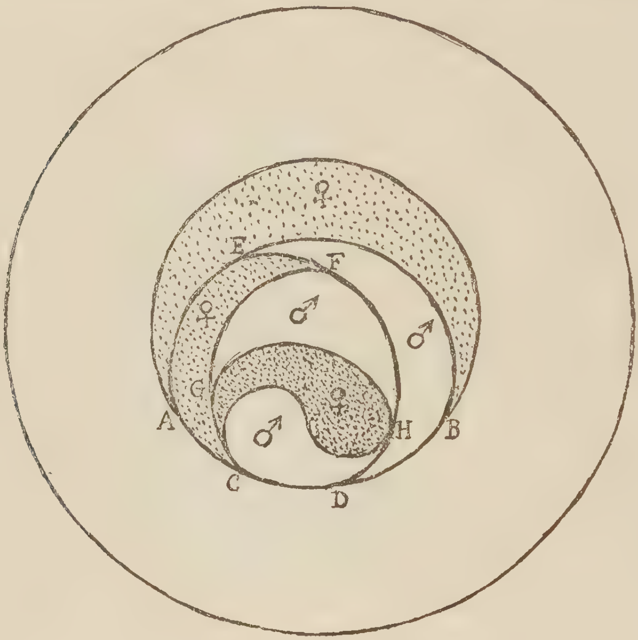


Fig. 3

Zone of manifested Characters and Sexual Dominance

amount of adherence,—this sex will literally *dominate* the other and make the corresponding characters prevail during the life of the individual: the other sex will then belong also, throughout life, to the series of latent characters before described.

So the nucleus of figure 3 is destined to become female, since the curved fixation planes AB + AC are greater than CD + DB. However, this

female will wholly resemble her father since the adherent paternal plasmas in CD, have eclipsed or dominated the maternal ones, which have been repelled back inside the nuclear sphere.

The first biologists who described karyokinesis (Strasburger, Fol, Bütschli Van Beneden, Hertwig) have attempted, in general, to attribute to it some relation to the transmission of character. Here we have attempted to define and limit this relation. It is enough to admit that the successive phases of karyokinese tend to maintain, in the new-born cells, the same type of accommodation and fixation of the unfixed plasmas both with each other and with the specific plasma (that is to say chromosomes), which was found in antecedent cells.

These interactions between both sort of plasmas, their contacts, their mode of attraction and fixation, are therefore what constitutes life.

The whole future individual has therefore its geometrical (design) recorded and systematized inside that invisible protoplasmic sphere, which each histologist is able to fix, section and observe. All these figures ought to be considered as compulsory orientation planes, for future cell lineages. If an egg is to have its plasmas differentiated, as we have just considered in this study, it would not appear as a condensation, a reduced model of the whole organism, but rather as a sketch of the necessary scaffoldings along which the materials of that growing organism will come to form together and to be coördinated.

SEX DETERMINATION IN ROTIFERS

A. FRANKLIN SHULL

University of Michigan, Ann Arbor, Michigan

While there is some objection to applying the term sex determination to the alternative modes of reproduction in the rotifers, to do so has the advantage of recognizing a striking difference between the life cycle of the rotifers and those of most other animals which reproduce by the parthenogenetic and bisexual methods. In these latter more common forms, the sexual members of the cycle arise from parthenogenetic eggs which can develop in no other way, and from parents that are identical, or even from the same parents. The aphids and Cladocera are chiefly of this type. Even in the phylloxerans in which the sexual females and the males are derived from different parents, both develop from eggs that are necessarily parthenogenetic. In the rotifers, on the contrary, while the males develop parthenogenetically, they are derived from eggs that may be fertilized. If fertilized, they yield females instead. The sex of rotifers is thus much more closely related to the mode of reproduction than in the aphids, Cladocera and phylloxerans. To describe as sex-determining those phenomena which lead to changes in the mode of reproduction in rotifers is a recognition of this more intimate relation.

The factors leading to changes in the life cycle and to the determination of sex are various. Among the most important of these is heredity. This is demonstrated by the fact that different parthenogenetic lines employ the two modes of reproduction and produce the two sexes in very different ratios, even though reared under identical conditions. Crosses between lines exhibiting different ratios of male-production have been effected with results that can not for the present be reduced to any system. It is probable that a number of hereditary factors are involved in producing these differences.

Though the hereditary factors concerned with the life cycle and determination of sex are important—probably the most important—the extent to which they come to expression in any family may be greatly altered by environmental conditions. A long list of chemical substances has been found, each of which when dissolved in the water in which the rotifers live

reduces the proportion of sexual reproduction and hence of males. Some of these substances are ammonium carbamate, and other ammonium salts, cane sugar, butyric acid, and creatin. Concentrated solutions of some of these may practically exclude male-production even in lines which from hereditary factors alone produce many males. These substances are so unlike in their chemical properties as to throw no light on the cause of their common effect on the life cycle of the rotifers. Probably there is some unstable feature of the protoplasm which is readily disturbed by a variety of untoward conditions.

Increase of male-production appears to be caused by very dilute solutions of certain substances (calcium chloride), but more particularly by the kind of food. It was first discovered by Whitney, and later verified in my own work, that green food, such unicellular organisms as Euglena and Chlamydomonas, greatly increases the amount of male-production. Direct tests appear to show that part of this effect is due to the oxygen liberated in the water by the green organisms, but the major portion of it is evidently a phenomenon of nutrition, not of quantity but of kind.

Another change in the amount of male-production in a given line of rotifers appears to result from long-continued parthenogenesis. Lines which produce many males in the early generations following the fertilized egg produce successively fewer of them in later parthenogenetic generations. Some biologists have attributed this well known change to an unsuspected change of environmental conditions, others to long subjection to uniform conditions, rather than to any internal phenomenon. Argument against the first suggestion is found in the fact that young lines introduced into the supposedly deteriorated conditions nevertheless produce many males. Against the second suggestion is the fact that hybrid lines from a cross known to result in high male-production produced many males under conditions in which similar hybrid lines produced long before were already showing a marked decline of male-production. In my opinion there is a cumulative change that is internal and largely independent of environment. Probably the progressive diminution of male-production is in no way due to parthenogenesis, but to the absence of bisexual reproduction. It might be more correctly described as due to long continued undisturbed metabolism, rather than long continued parthenogenesis. If this conception is correct, this progressive change would occur to the same extent in six months, regardless of whether only one generation or sixty generations had been produced in that time; and it is only because of the rapid succession of generations that the cumulative change can be expressed in a reduction in the number of males.

None of these changes in the number of males produced appears to affect the hereditary nature of the line involved. When diminution of male-production is caused by substances in the water, removal of the unusual environmental condition immediately restores the male-production to its former high level. And when long absence of bisexual reproduction leads to a decline of male-production in a given line, the ability of that line to transmit capacity for male-production in crosses remains unimpaired.

Crucial events in the determination of the mode of reproduction or of sex, in so far as they relate to a given individual, occur only in a very limited period of time. The mode of reproduction to be employed by any parthenogenetically produced female is fixed in a period not over two or three hours long, probably less, in the maturation of the egg from which she develops. The sex of any parthenogenetically produced individual is fixed in a corresponding short period in the maturation of the egg from which that individual's mother develops. Since the critical part of the maturation of an egg occurs while the egg is still in the oviduct of the female, the sex of a male rotifer is determined in the body of its grandmother. Attempts to alter the mode of reproduction or the sex, by means of environmental conditions, before or after the maturation period just referred to, have invariably failed.

The event in the maturation of an egg which determines whether the female developing from it shall produce males or females is still unknown. Apparently there is no change in the chromosome number. Although males differ from females in the number of their chromosomes, there is no such difference between the mothers of males and mothers of females. There are twelve chromosomes in each of these types of female. Yet these females are irrevocably differentiated from one another by something. No female ever produces both males and females by parthenogenesis.

What change occurs in maturation to differentiate the two types of egg so sharply from one another can only be conjectured. Probably it is a definite chemical change in the proteins of the egg. That change may have to do with the proteins of the chromosomes. A similar chemical change perhaps occurs in the germ cells of other animals in which sex is associated with chromosome number, as it appears to be in man; but presumably in such forms it is not the number that is important. If in such species the chemical change involves also a change in the number of chromosomes, while in the rotifers the chemical change leaves the chromosomes number unaltered, the two cases are brought under one point of view. Perhaps the nature of this chemical change, if such it is, will never be known; but in the search for it in the rotifers, it is not unlikely that the way is pointed by the fact

that fertilized eggs all yield females. These eggs, without fertilization, produce males, and fertilization changes the sex as in the honey-bee. The essential chemical event, as far as sex is concerned, produced by fertilization may turn out to be the same as the event occurring in the maturation of the female-producing parthenogenetic egg.

The above suggestions recall the metabolic theory of sex. The fact that the supposed chemical change in the rotifers occurs suddenly, that is, in a very short period of time, may make the chemical change theory seem incompatible with the general metabolic theory; for the metabolic theory usually assumes a gradual change, with a series of finely graded conditions between the two extremes which represent male and female. The incompatibility is not real, however. There may be in the rotifers a series of metabolic processes of some other nature, or a variable metabolic condition, at some stage of which the sudden event in maturation occurs. I have avoided saying that the decisive event may occur at a certain "metabolic level," because this expression has been used by those who have in mind some specific sort of change, such as the consumption of oxygen or the storage of fats or lecithin. It may well be that the chemical change that takes place in the rotifers can not be described in terms of "level." However, although the current language of the metabolic theory may not be applicable to my conception of what occurs in the rotifers, it is apparent that there is nothing in the phenomena of sex determination in the rotifers, as far as these phenomena are known, which makes the metabolic theory of sex untenable.

SOME DATA ON CONTROL OF SEX IN CLADOCERA

ARTHUR M. BANTA AND L. A. BROWN

Carnegie Institution of Washington, Cold Spring Harbor, New York

One of us has reared eight species of Cladocera under laboratory conditions for periods ranging from 11 to 118 months, from 39 to 448 generations (see table 1). In spite of the fact that reproduction has been solely by parthenogenesis, the stock has apparently lost nothing of its original vigor and there is an entire lack of indications of degeneration or of the occurrence of abnormal individuals. Hence there is no evidence for an internal sexual cycle but on the contrary there is excellent ground for believing that parthenogenetic reproduction may be continued indefinitely and, by implication, that sex control is through external factors.

Sex phenomena in Cladocera consist in the production of eggs requiring fertilization and of males. The parthenogenetic egg of Cladocera, which is the prevailing type, passes into the mother's brood chamber and within about two days has developed into a freely swimming daphnid quite resembling the mother except for its small size. The sexual egg is much larger than the parthenogenetic egg. There are never more than two of the former in a clutch whereas there may be 12 to 40 of even more parthenogenetic eggs in a single clutch. When sexual eggs are about to be produced the brood-chamber becomes covered by an ephippium, a heavy dense development of the carapace. This ephippium when cast off serves as a resistant case for the fertilized sexual eggs, which ordinarily develop only after a considerable dormant period.

Circumstantial evidence that the sexual forms are called forth by environmental factors had been obtained from two sources before direct experimentation upon the subject was undertaken. It was noted that, whereas males and ephippial females did not often occur among our laboratory stock, when they did appear they were usually noted in more than a single strain. On one occasion many strains in the laboratory produced males within a comparatively short time. At another time males and sexual females were abundant among three species of Cladocera (Daphnia pulex and two species of Moina) in an outdoor pond from which our culture water was at that time obtained. Sexual forms appeared at the same time among several of our laboratory lines reared in water from this pond.

The first direct experimentation on the control of sex was with culture water from two different ponds—one pond containing males among its wild Cladocera population and the other lacking them. Males appeared with considerable frequency among the bottles made up with culture water from the pond which contained males among its wild Cladocera population; no males appeared in bottles containing culture water from the other pond. A second series of experiments consisted in rearing Cladocera in culture water treated with precise amounts of NaOH and HCl. These experiments were frequently unsuccessful in bringing about the production of males, but when males occurred they appeared in bottles in which they had been anticipated,—and not elsewhere.

TABLE 1

Periods of time and generations of descent of some laboratory lines of Cladocera

SPECIES	LINE NUMBER	DATE CULTURE BEGUN	NUMBER OF GENERATIONS TO 9/21/21	NUMBER OF MONTHS
Daphnia pulex	695+	11/17/11	448	118
	695−	11/17/11	417	118
	713−	11/22/11	429	118
	714+	11/22/11	426	118
	714−	11/22/11	437	118
	984	5/16/17	193	52
D. longispina	898	10/3/16	220	60
Simocephalus exspinosus	795+	12/11/14	297	81
	795−	12/11/14	286	81
	740+	8/15/12	378	109
	740−	8/15/12	384	109
S. vetulus	1043	10/28/20	39	11
S. serrulatus	859	9/28/15	252	72
Moina affinis	851	7/15/15	382	74
M. macrocopa	1012	5/27/18	276	40
M. rectirostris	1010	5/27/18	248	40

The case then rested until the present collaborative work upon the problem was undertaken. This work is still uncompleted and in progress but may be briefly reported upon here.

It was found, as Grosvenor and Smith[1] had previously found for Moina rectirostris, that the simple expedient of crowding the females from early

[1] The life cycle of Moina rectirostris. Quart. Jour. Mic. Sci., 58, 1913, pp. 511–522.

life until they produce young causes the production of a proportion of males. Our procedure was as follows. Instead of only one (or two) females being reared in approximately 75 cc. of culture water, 10 or 20 females were reared in this quantity of culture water. Each experiment utilized the young of a single brood from one mother, hence any difference in sex of young in the crowded and uncrowded bottles is attributable to the effect of the crowding.

The data for some of the lines tested are shown in table 2. The data for a given experiment are placed in horizontal lines. (Experiment 25 was conducted in duplicate, hence there are two horizontal lines for it.) The totals and percentages of males by 1st, 2nd, and successive broods are placed below the tabulated data for a given line. Thus in experiments with Daphnia pulex Line 1005, Experiments 25 and 31, there were in the first broods of all "ten-mother" bottles 148 females and 22 males or 12.9 per cent males; in the second broods 171 females and 57 males or 25 per cent males; and in the third broods 64 females and 97 males or 60.2 per cent males; in all broods of ten-mother bottles for this line there were 385 females and 176 males or 31.3 per cent males. Data for Simocephalus exspinosus Line 795 plus, and for Moina macrocopa Line 1012 are also given in this table.

The D. pulex data show that none of the six uncrowded mothers in three bottles produced any males in a total of 18 broods and 245 young; while the 30 crowded mothers in three bottles produced 12.9 per cent, 25 per cent, and 60.2 per cent males, in their first, second and third broods respectively, or an average of 31.3 per cent males; and the 20 crowded mothers in a single bottle produced 0 per cent, 4.5 per cent, and 20 per cent males in the different broods or an average of 6.4 per cent males. The S. exspinosus data show 0 per cent males in two-mother bottles, 50 per cent males in a ten-mother bottle, and 68.2 per cent males in two twenty-mother bottles. The M. macrocopa data show 10.7 per cent males in the uncrowded bottles, 51.7 per cent males in the ten-mother bottles, and 48.6 per cent males in the twenty-mother bottles.

These are very limited data but they indicate that crowding is a ready means of bringing about the production of males. The fairly limited range of percentages of male young in the ten- and twenty-mother bottles of M. macrocopa suggests the possibility that in crowded bottles of this strain of M. macrocopa 50 per cent males is approximately the expectation. In the second brood of two two-mother bottles of Moina, and in the third brood of two other two-mother bottles of the same series males appeared. Either the factor calling forth males in crowded bottles may supervene to influence later broods in two-mother bottles or some other factor may also be opera-

tive here. In the one experiment with S. exspinosus involving a ten-mother bottle no males appeared until in the second broods. The crowding effect seems not to have become manifest early enough to influence the first broods.

The result common to the three species is 0 per cent or a low percentage of males in uncrowded bottles, 31 to 52 per cent males in ten-mother bottles and 6 to 68 per cent males in twenty-mother bottles.

Similar experiments, some as successful, others less successful than those shown in table 2, have been tried with other strains of Cladocera. No strain at all adequately tested has failed to show some response to the effects of crowding (though in two strains the sexual manifestation has been in the production of ephippial eggs rather than males). Definite results have been obtained for Moina affinis, M. macrocopa, M. rectirostris, Daphnia pulex (three morphologically different forms of D. pulex have given positive results), a species of Ceriodaphnia (one experiment only), Simocephalus vetulus, S. exspinosus and S. serrulatus.

The specific environmental factor involved in the causation of males in crowded bottles is being sought. Formerly crowded bottles, with their recent population removed, when used again as culture bottles do not give males. Hence the cause of the crowding effect does not persist. The production of males is not due to mere scarcity of food since recently crowded or old depleted bottles give very few young yet the young are females just as those produced by uncrowded mothers with abundant food. The young produced by mothers reared in clear pond water, again with scarcity of food, are females. Hence age of culture medium, scarcity of food, or accumulation of excretory products (unless they are products of a very transitory nature) is apparently not the causative factor here.

A single experiment suggested that the environmental factor involved may be the accumulation of carbon dioxide or depletion of oxygen in the crowded bottles. This will be tested further.

Scanty data have been obtained bearing on the critical period during which the crowding effect must be operative. Table 3 presents some of the data bearing on this point. The data show that in their first broods none of the mothers in uncrowded bottles, or kept in crowded bottles less than about forty-eight hours, produced any males. From those kept crowded until fully forty-eight hours of age or older 45 per cent of the young were males, while those crowded all the time produced 34.1 per cent males.[2] The

[2] The higher percentage of males from those mothers crowded all the time than from those isolated between 48 and 76 hours is possibly not significant though it is possible there is a selective elimination of males under conditions of severe crowding.

These data are not entirely satisfactory to the writers. The precise stages of development of the eggs were not known. In later experiments accurate observations will enable us to know whether the eggs have been laid or at approximately what stage of their ovarian development sex is irrevocably fixed.

TABLE 2

Data of some Cladocera sex control experiments

SPECIES AND LINE NUMBER	EXPERIMENT NUMBER	UNCROWDED BOTTLES								CROWDED BOTTLES															
		Two mothers								Ten mothers								Twenty mothers							
		First brood		Second brood		Third brood		Fourth brood		First brood		Second brood		Third brood		Fourth brood		First brood		Second brood		Third brood		Fourth brood	
		♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
Daphnia pulex (Line 1005)	25	18	0	36	0	13	0			66	0	70	17	12	64										
		20	0	38	0	19	0			48	22	69	18	23	22										
	31	23	0	49	0	29	0			34	0	32	22	29	11			112	0	85	4	60	15		
		61	0	123	0	61	0			148	22	171	57	64	97			112	0	85	4	60	15		
		0%♂		0%♂		0%♂				12.9%♂		25%♂		60.2%♂				0%♂		4.5%♂		20%♂			
		All two-mother bottles								All ten-mother bottles								All twenty-mother bottles							
		245 ♀		0♂		*0%♂*				385 ♀		176♂		*31.3%♂*				276 ♀		19♂		*6.4%♂*			
S. exspinosus (Line 795+)	32	30	0	63	0					30	0	12	42					14	34	6	8				
	33	27	0	29	0													21	46						
		57	0	92	0					30	0	12	42					35	80	6	8				
		0%♂		0%♂						0%♂		77.8%♂						69.5%♂		57.1%♂					
		All two-mother bottles								All ten-mother bottles								All twenty-mother bottles							
		149 ♀		0♂		*0%♂*				42 ♀		42♂		*50%♂*				41 ♀		88♂		*68.2%♂*			

Moina macrocopa (Line 1012)	21	34	0	29	7	38	0			29	77	51	0	57	0			54	64	31	30	29	0		
	29	50	0	44	0	33	0	50	0	60	81	30	34	97	45	17	76	74	180	54	33	86	110	17	43
	30	42	0	0	32	26	0	9	0	5	137	41	11	34	56	50	35	50	155	68	31	81	92	51	55
	50	13	0	26	0	8	14			140	0	0	135	32	1										
	51	15	0	24	0	0	4											113	0	0	18	93	3		
	54	15	0	20	0													175	70	45	78				
		169	0	143	39	105	18	59	0	234	295	122	180	220	102	67	111	466	469	198	190	289	207	68	98
		0%♂		21.4%♂		14.6%♂		0%♂		55.7%♂		59.6%♂		31.6%♂		62.3%♂		50.2%♂		48.9%♂		41.7%♂		59.0%♂	
		All two-mother bottles								All ten-mother bottles								All twenty-mother bottles							
		476♀		57♂		*10.7%♂*				643♀		688♂		*51.7%♂*				1021♀		964♂		*48.6%♂*			

TABLE 3

Length of crowding and sex of young. Moina macrocopa (first broods only)

EXPERIMENT NUMBER	LENGTH OF CROWDING														
	0 hrs.			20–25 hrs.			31–46 hrs.			48–76 hrs.			All time (72–96 hrs.)		
	♀	♂	% ♂	♀	♂	% ♂	♀	♂	% ♂	♀	♂	% ♂	♀	♂	% ♂
54	15	0		15	0		17	0		0	19		155	70	
										0	18				
										21	0				
										20	0				
	15	0	0	15	0	0	17	0	0	41	37	47.4	155	70	31.1
65	16	0								15	0		128	0	
	19	0								16	1				
										12	0				
	35	0	0							43	1	2.2	128	0	0
69	15	0		12	0		8	0		0	4		44	21	
	15	0		11	0		5	0		0	6				
							7	0							
							4	0							
	30	0	0	23	0	0	24	0	0	0	10	100.0	44	21	32.3
70	16	0		15	0					6	0		31	39	
	15	0		13	0					0	11				
	31	0	0	28	0	0				6	11	64.7	31	39	55.7
71	18	0		19	0					0	16		24	101	
	17	0		20	0					15	0				
										0	11				
										5	3				
										0	13				
										0	8				
	35	0	0	39	0	0				20	51	71.8	24	101	80.8
74	19	0		19	0		15	0					193	31	
	16	0		20	0		16	0							
	17	0					16	0							
	19	0													
	14	0													
	85	0	0	39	0	0	47	0	0				193	31	13.8

TABLE 3—*Continued*

EXPERIMENT NUMBER	LENGTH OF CROWDING														
	0 hrs.			20–25 hrs.			31–46 hrs.			48–76 hrs.			All time (72–96 hrs.)		
	♀	♂	% ♂	♀	♂	% ♂	♀	♂	% ♂	♀	♂	% ♂	♀	♂	% ♂
78	20	0		25	0					15	0		127	102	
	21	0		21	0					0	15				
										15	0				
										13	0				
	41	0	0	46	0	0				43	15	25.9	127	102	44.5
Totals, and per cent ♂'s of totals	272	0	0	190	0	0	88	0	0	153	125	45.0	702	364	34.1

critical period seems to be around forty-six or forty-eight hours,—about the time the eggs pass into the brood chamber. This critical period is not precisely enough localized as yet but these data suggest that the crowding condition must be operative until (or after) the eggs are laid and maturation is undergone. Hence it seems probable that in Cladocera, sex is not irrevocably fixed until the maturation of the parthenogenetic egg, but that in a certain stage of the egg the sex of the forthcoming young is subject to control through environmental influences.

DISTURBANCES IN MAMMALIAN DEVELOPMENT PRODUCED BY RADIUM EMANATION

HALSEY J. BAGG

From the Huntington Fund for Cancer Research, Memorial Hospital, and the Department of Anatomy, Cornell University Medical College, New York City

The effect of radium on developing animals has been the subject of several researches since the early work of Bohn (1), in 1903, upon the ova and larvae of the sea-urchin. Experiments on developing nematodes, molluscs, amphibians, fishes, and birds are associated with the names of Perthes (2), P. Hertwig (3), Mottram (4), Tur (5), Schaper (6), O. Hertwig (7), G. Hertwig (8), and Bataillon (9). These investigators report the retarding effects produced by radiating the ova and developing embryos, showing the particular susceptibility of the nuclei of the cells, a general slowing up in the developmental processes, especially in the case of the central nervous system, and the total disturbances, depending upon the period of development when the radiation was applied, resulting in the formation of monstrosities conforming more or less to a general type.[1]

Similar experiments concerning the effects of X-rays on development have been conducted by many investigators. After exposure to X-radiation, Perthes (10) and Hastings (11) noted abnormal cell division, and a retardation in the development of the ova of Ascaris megalocephala. Bordier (12), and Hastings, Beckton and Wedd (13) reported similar results following the irradiation of various insects. Gilman and Baetjer (14) after radiating the ova of Amblystoma, and Baldwin (15) the fertilized ova of frogs, were able to produce a fairly constant type of developmental defect.

Injurious results have followed in all cases where mammals have been exposed to X-radiation. Försterling (16), Langfellner (17), Krunkenberg

[1] In connection with the above statement, and applying to X-ray treatments as well, the question of dosage is an important one. A survey of the literature shows that there was a very wide range in the severity of the dose employed, and in several cases the experimental settings were inadequately described. (Bohn used "some centigrams" of pure radium bromide for from twenty minutes to two hours.) The amount of radium metal used in the investigations that have been mentioned varied from 2 mgs. to 35.1 mgs., and the time from a few seconds to several hours. The deleterious changes in the animal tissues varied with the amount of radium and the time of exposure.

(18), and Walter (19) have shown that when any particular part of a young animal is exposed to a sufficient amount of radiation, that part fails to reach its normal size, and is unable to exercise a full degree of function. Langfellner (17) exposed pregnant guinea pigs to X-rays three days before term. The young, born a short time after treatment, were all dead.

Arrests in development and the production of abnormal types may be induced not only by radio-activity, but by many physical or chemical agents. Abnormal temperature changes, treatment by many chemicals, lack of oxygen supply, or the overabundance of carbon dioxide, etc., have produced marked changes in the developing embryo.

The present experiments are mainly concerned with disturbances in mammalian development, before and after birth, as a result of exposing the embryos of rats, at various times during the prenatal period, to irradiation from radium emanation. The effect on the embryos following radiation of the mother at varying intervals *before* mating was also determined. These experiments were designed not only to study the factors underlying the production of abnormal types, but through an examination of the abnormal to gain a clearer insight into the nature of normal development and differentiation.[2]

METHODS AND APPARATUS

Two methods were used for applying the radium emanation. In the first method an "active deposit" was obtained by exposing a definite quantity of common salt to a comparatively large amount of radium emanation, about 500 millicuries were used, or the amount of radium emanation initially equivalent to 0.5 gram of radium metal. To the radio-active salt thus produced sufficient water was added to make a physiological solution. The pregnant rats were injected subcutaneously in the shoulder region, and intravenously through the caudal vein. Three to four minims constituted the usual dose. Because of the rapid loss of radio-activity of these solutions, the injections were made immediately after the preparation. The details involved in preparing and measuring the doses, as well as the methods for protecting the experimenter, are described elsewhere, (20) and (21). The activated solution exhibited all the known phenomena of radium metal itself, alpha, beta, and gamma rays were present, but the greatest physio-

[2] Dr. J. F. Gudernatsch was a co-investigator with the writer during the year 1919. A preliminary report of the work done with him at that time is given in the Proceedings of the Society for Experimental Biology and Medicine, 1920, xvii, 183.

logical effects were probably due to alpha-ray activity. After long experimentation a dose of 5 millicuries was found to be the maximum applicable to the aims of this experiment. In the second method, gamma-ray radiation was applied through the ventral body wall of pregnant rats at nearly full term. A large amount of radium emanation was used, an amount equivalent to 1.5 grams of radium metal, filtered by 2 mm. of lead and 0.5 mm. of silver. The source of emanation was 1 cm. away from the animal. The applicator, called a "lead tray" in clinical usage, was 6 cm. in diameter and 1.5 cm. high. This was placed in the bottom of a small wire cage, 10 by 13 cm. in diameter and 10 cm. high, and was covered by a thin sheet of cardboard. The animal was placed on this paper immediately above the applicator.

Preliminary tests showed that a dose of about 1300 millicurie hours was sufficient to produce developmental arrests in the embryos without killing the pregnant animals. Doses as high as 2900 millicurie hours, however, were successfully used in some cases. The embryos were killed by ether, and histological material procured at various periods after the treatment. The tissues were fixed in Bouin's solution, cut in serial section, and stained with haematoxylin and eosin.

EXPERIMENTAL RESULTS

Series A. Injections of radio-active solutions

1. Subcutaneous injections after mating. Sixty-five, full grown, normal, pregnant rats were treated in this series. They were divided into four groups, each treated at different periods after mating. Ten pregnant females were injected 7 days after mating; twenty-four, 10 to 14 days after, twenty-one, 15 to 17 days after, and ten, 18 to 21 days after mating. Many of the animals were killed at weekly intervals after treatment, although some were allowed to reach full term.

Various degrees of developmental disturbances were noted, as shown in the following groups:

1. There was a large number of cases where no embryos developed, or many began development and were early absorbed or aborted. The females in which no embryos were found, although they were definitely considered pregnant before treatment, occurred in the cases treated soon after mating, and in the instances where females were autopsied a considerable time after treatment. Figure 1 shows the remnants of maternal and embryonic structures, and from the size of the placentae one can see that the fetuses had

reached a fair degree of development before the radiation retarded the normal physiological processes. In one case, see figure 2, a small ovoid sac was found attached to the uterine wall by a thin stalk. This apparently represented the remnants of a former embryo and placenta. Extravasated blood and cell detritus were found in this sac, and a great many large cells of an epithelioid nature that probably belonged to the former embryonic syncytium. The wall of this cyst was formed by fibrous connective tissue.

2. Embryos were killed by the treatment, but were removed from the mother and preserved before they were absorbed. They showed various extravasations of the vessels of the subcutaneous connective tissue, within the meningial sinuses, and mainly along the dorsal mid-line of the body. Figure 3 shows a typical example of such a lesion which was situated in the mid-dorsal line. The mother of this embryo, no. 1167, was mated on April 22, 1919, injected with 4.9 millicuries on May 7, and was killed two days later. When the embryo was cut in serial section, it showed that the hematoma in the dorsal subcutaneous tissues had exerted sufficient pressure upon the spinal cord to produce at one place a complete dislocation. Microscopical examination of the viscera showed no pathological changes. Not all the fetuses of a litter were affected in the same degree. In one case 7 fetuses were found, 3 showing haemorrhagic lesions, 2 beginning to macerate, and 2 in the process of absorption. This difference in resistance was due either to the higher or lower vitality of the embryos themselves, or to the amount of radio-activity which passed the placentae. In another case the fetuses, although injured, were carried to full term, and among a litter of 6 young, 2 were apparentlynor mal and 4 showed haemorrhagic spots on the head, face, and along the dorsal mid-line of the body.

3. Several young of a single litter showed areas of extravasation and were born alive. Their mother died, however, and foster mothers refused to nurse them.

4. Eight litters gave normal living young. This number is low, because as previously stated, many pregnant rats were killed by the experimenter at various intervals after treatment. The average number of young per litter was 4.8, as compared with 6.5 per litter for the control rats, but the probable errors indicate that this difference is, most likely, not significant. Only one litter, containing 4 young, survived after a treatment given 7 days after mating. Several of the rats of this group, which had apparently escaped the full radium exposure during the uterine period, or perhaps they were more resistant to it, when mated *inter se*, produced litters of apparently normal young of normal fertility. The offspring of

these animals, about 20 in number, were observed for two generations, but no abnormalities were noted.

2. *Subcutaneous injections before mating.* Seventy-seven females were treated in this group, 11 died as a result of the injection before they were mated, while several were killed at weekly intervals after mating, and some were allowed to continue to full term. Thirty-four animals were injected between 5 and 7 days before mating; seventeen, 10 to 14 days before; and fifteen, 20 days before mating.

Only three litters in this group showed abnormal young. The most interesting was a litter of 7, in which case the female was treated with 4.2 millicuries, 22 days *previous* to fertilization, and the fetuses, approximately 16 days old, showed very pronounced areas of extravasation, which in one case covered a large area on one side of the head and a few small scattered areas on the other side. These areas were not only along the dorsal midline, but also on the lateral surfaces of the body as well (see fig. 4). The lesions were much more widely distributed and more variable in size, than in the cases recorded under section 1. Although the conditions that produced these results were many times repeated, the above is the only case where positive data were obtained. Usually the female had either been rendered sterile, or the young were killed and absorbed at the early stages. There were two other cases, however, where young were found with haemorrhagic areas, and these occurred in a group of females that were treated 7 days before mating. Female 85 was given a dose of 6.6 millicuries on November 7, 1919. It was mated on November 14, and as 3 young were born December 11, fertilization took place about 14 days after the treatment. Two of the young were apparently normal, but one showed a large haemorrhagic area, which involved most of the right side of the snout, the right eye, and a portion of the lower jaw on that side. This area disappeared after three days. Female 99, injected and mated at the same time as female no. 85, received a dose of 5.6 millicuries. Five young, 3 males and 2 females, were born on December 13, making the date of fertilization about 16 days after treatment. One male and one female showed definite haemorrhagic areas on the face. Consideration of these cases will be deferred until later.

Seventeen females that following treatment were killed at varying intervals after mating, showed markedly haemorrhagic or cystic ovaries, and the presence of much congested uteri. In these cases radium emanation apparently had either so altered the maternal tissues as to prevent fertilization, or development when started was soon followed by the death of the embryo and its absorption. Many nodules were found in the uteri

in which it was impossible to differentiate between embryonic and maternal structures.

The remaining females (as previously stated, 11 died between the period of treatment and mating) produced either full term normal young, or young apparently normal at autopsy. Several of these living young grew normally, were mated *inter se*, but produced no abnormal offspring although observed for two generations.

3. Intravenous injections after mating. The intravenous injections were primarily planned to act as a check on the series of subcutaneous treatments. The object was to determine the immediate reactions that might occur in the embryo as a result of injecting a comparatively large dose of radio-active solution into the circulation of the pregnant female, and whether these reactions would be similar to those already recorded for the subcutaneous series. The toxic reactions were so prompt and fatal that it was not necessary to treat many animals to settle this point. A typical case is that of female no. 123. This animal, of about 19 days pregnancy, was treated with 30 millicuries injected directly into the blood stream through the caudal vein. This was six times greater than the usual dose in the first two series. Three young were born dead 24 hours later. They showed very definite radium changes, typical of those already recorded for the subcutaneous series. A fetus was found still attached to an apparently normal placenta, but a characteristic area of extravasation was found over a considerable portion of the left side of the head. Another embryo showed two comparatively small haemorrhagic areas along the dorsal mid-line, and the placenta in this case is also normal. The third fetus in this litter was apparently normal, but the placenta had acted in the nature of a "shock absorber" in protecting the fetus from exposure to the radio-activity, and it was so swollen and completely filled with blood as a result of its injury, that it had the appearance of a large haemorrhagic sac.

Series B. Results from radiating nearly full term pregnant rats with gamma-ray radiation

Ten rats were treated at the end of about 19 days of pregnancy. It was found that exposure to about 1350 millicuries hours of radium emanation was sufficient to produce very decided changes in the embryo and yet leave the pregnant females sufficiently uninjured to be able to nurse their young and care for them until after the weaning period. When the dose was increased to 3378 millicurie hours the young were severely injured, and were either killed outright, or died 2 or 3 days after birth.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The following are the conditions that resulted in the first generation of animals treated in utero with a dose of about 1350 millicurie hours.

1. The young of each litter were born two or three days after the treatment, alive and apparently normal.

2. About 10 days after treatment, about half of each litter became markedly anemic, showed symptoms of diffuse edema and promptly died. There was an easily recognizable slow development of meningial and spinal cord haemorrhages, similar to those already described as a result of treatment by radio-active solutions. In one case a young rat was found showing a typical haemorrhagic area in the region of the frontal lobes. The slow development of this lesion could be easily noted through the thin, transparent scalp. This young was one of several treated in utero with 1350 millicurie hours of gamma-ray radiation on February 21, 1920. It was born 2 days later, and died on March 3. Another rat in this litter

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Fig. 1. Two Well-Developed Placentae Are Shown at the Left Attached to a Uterus Which Has Been Partly Opened

The remnants of embryonic tissue are superimposed on the placentae. At the right is a placenta which has been dissected from the uterus, and shows more clearly the remains of embryonic material, here represented as a lighter area in the upper portion of the drawing. Female mated April 22, 1919, injected May 7, killed May 16. Dose = 4.6 millicuries (subcutaneous).

Fig. 2. A Stalked Sac Partly Dissected from the Uterus, Showing the Remnants of a Former Embryo and Placenta

Female mated April 22, injected May 7, killed May 16. Dose = 4.8 millicuries (subcutaneous).

Fig. 3. This is a Dorsal View of a Rat Embryo, Showing a Characteristic Area of Extravasation Due to the Treatment of the Mother During Pregnancy

Female mated April 22, injected May 7, killed May 9, at which time seven fetuses were found about fifteen days in development. Two of the litter were macerated and two absorbed. Dose = 4.9 millicuries (subcutaneous).

Fig. 4. Areas of Extravasation Are Shown in the Three Views of this Embryo, Similar to the Condition Shown in Figure 3

But in this case resulting from treating the mother 22 days before fertilization. Note the wide distribution of the lesions. Female injected April 22, mated May 12, killed May 30. Seven fetuses were found, 15 to 16 days old. Dose = 4.2 millicuries (subcutaneous).

Fig. 5. There is An Extensive Meningial Extravasation Over a Considerable Portion of the Hemispheres, and a Hemorrhagic Lesion is Shown on the Reflected Skin from the Dorsal Interscapular Region

This animal was treated in utero with 1350 mc. hrs. of gamma-ray radiation on February 21 and was born apparently normal on February 23. It died on March 2.

shows the presence of three distinct hemorrhagic areas, a small frontal lesion, a fairly extensive one in the occipital region, and a small lesion in the subcutaneous tissues in the thoracic region, near the mid-dorsal line on the left side of the body. This animal also died on March 3. A third animal belonging to the same litter is shown in figure 5. Here is seen a still more acute reaction, as shown by the fact that the animal died a day sooner than in the two cases above, and there is an extensive area of meningeal hemorrhage which covers most of the dorsal portion of the brain, involving the frontal and occipital regions and the medial area between, as well as a considerable portion of the right temporal area. In addition, a distinct, rounded hemorrhagic lesion may be noted on the reflected skin on the left side of the body. This lesion occurred in the mid-shoulder region of the back.

The heads of several of the young rats showed marked lateral compression. In one case a hemorrhage so affected the spinal column as to produce complete paraplegia. The tissues of these animals were studied histologically. Save for the mechanical disturbances produced by the presence of the extravasated areas, the most marked pathological conditions were seen in the liver and intestines. In the first case there was a pronounced fatty degeneration of the hepatic cells, and in the second, a desquamation of the lining cells of the intestinal mucosa.

3. It is interesting to note that the other half of each litter survived the treatment, grew to a normal size, and some animals have lived for over 18 months. They showed the effects of the late uterine treatment by the following arrests in development:

a. The first pathological condition that was noted was that the eyes became smaller, the pupils opaque, and there finally was a complete, or nearly complete closing of the lids and total blindness. This condition was first observed a short time after the eyes had opened. In one animal, which had grown to normal size and weight for its age, the left eye was nearly completely closed, both pupils were opaque, but the right eyelids were slightly more opened than those of the other side. The animal was one of a litter treated in utero on March 8, 1920, was born six days later, and these observations were made on March 1, 1921. The dose in this case was 2920 millicurie hours of gamma-ray radiation, which was a dose higher than one usually tolerated.

b. Mating tests showed that both the males and females were completely sterile in the first lots, but subsequently a first generation female, that had been treated with 1350 millcurie hours, mated with a male similarly treated and gave birth to 9 apparently normal young.

c. Before these adult offspring of treated animals were killed for histological examination, their neurological reactions were very carefully studied. The animals, being blind, when startled assumed various defensive attitudes, but save for these reactions their behavior was remarkably normal. There was no ataxia in locomotion or in any of the feeding reactions, auditory acuity was normal, and there was no cutaneous hypoesthesia, or other sensory disturbances. Except for blindness, there was nothing to suggest abnormal sensory function.

d. When these animals were autopsied, marked developmental disturbances were noted in the condition of the central nervous system. The cerebral hemispheres were greatly reduced in size, and in several cases very little cortical material remained. Those portions of the brain that were ontogenetically older (the archiostriatum and the cerebellum) were apparently normal. The optic tracts were markedly atrophic. Correlated with this disturbance in brain development, the skull was found to be asymmetrical, narrow, thicker than normal, and concave in the frontal region.

One animal, which belonged to the same litter as those of section 2 of this series, was treated with 1350 millicurie hours on February 21, 1920, was born on February 23, and was killed December 31, 1920. This was one of the animals which (except for blindness) showed no abnormal neurological reactions. A dorsal view of the brain shows an apparently normal cerebellum and normal olfactory lobes, but the part of the brain which represents the rudiments of the hemispheres shows a great lack of development of cortical substances. A side view of the brain shows that the cortex is very thin indeed, not completely covered what should normally be the frontal, occipital and lateral aspects of the brain. The remains of the hemispheres do not sufficiently approach each other in the median line to cover the colliculi beneath. It was possible in this specimen to see the lateral ventricles through the transparent membranes. Several other brains have been studied which showed various degrees of developmental arrests resulting from radium treatment. In some cases the hemispheres were markedly reduced in size, were widely divergent in the median line and yet the pallium was complete over the entire surface. In all these cases there was marked optic atrophy. These brains are now being sectioned, and a study of them in greater detail will be the subject of a separate communication.

e. A histological study of the eye showed that the eyeball was reduced to one fourth the normal diameter. The retina was missing but traces of the choroid remained as a few scattered pigmental cells. The cornea was three times as thick as the normal and covered with four or five layers of opaque

squamons epithelium. The optic nerve was extremely small, not more than one third the normal dimensions.

f. The testes of the radiated animals were decidedly atrophic, and a comparison with the normal is shown in the photograph in figure 6. The diameters of the testicle alone (minus the epididymis) of the experimental

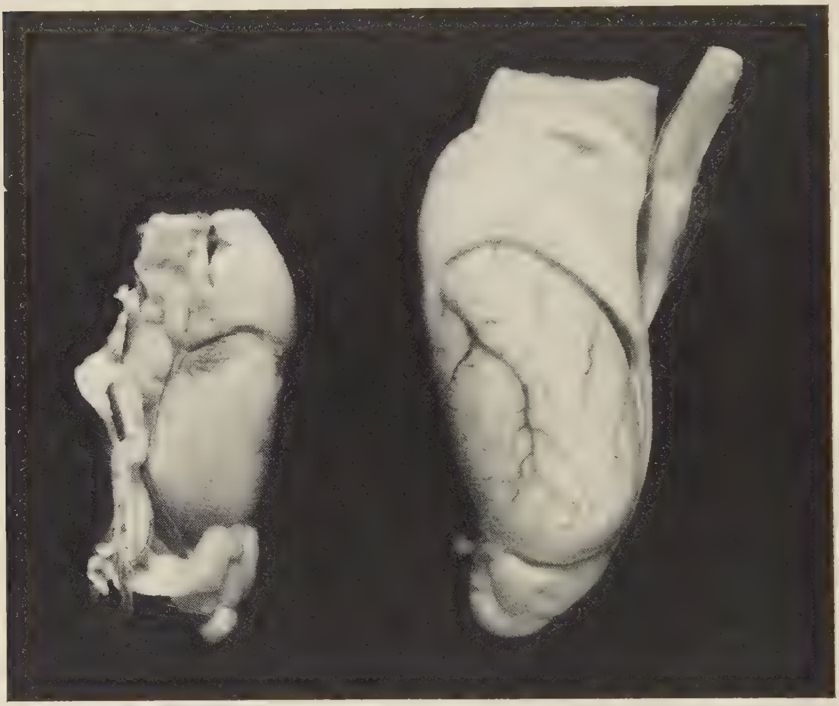

Fig. 6. At the right is shown a normal untreated testicle of a white rat surmounted by a well developed epididymis, which is partly obscured by fat. At the left is a radiated testis showing considerable atrophy. The single small lobe at the very bottom of the photograph represents the remains of the tail of the epididymis, the head and body of that part being completely missing. The animal was treated in utero on February 21, 1920, was born February 23, and was killed December 31, 1920. Dose = 1350 millicurie hours of gamma-ray irradiation.

animal was 14 mm. for the length and 7 mm. for the width, while the control measurements from normal animals of the same age and weight and with the same method of fixation were 21 mm. for the length and 11.5 mm. for the width. The epididymis of the radiated testis was practically missing. A small portion of the tail remained, but the head and body of the epididy-

mis had failed to develop. Histological examination shows that there is little evidence of spermatogenesis. Some tubules seem to contain imperfect spermatoblasts and forming spermatozoa, but the great majority of tubules show complete degeneration and loss of epithelial cells, and contain loose granular material, which in places is calcified. Some spermatic tubules are greatly dilated and filled with granular material. Very few interstitial cells are visible.

The ovary of the radiated animals was reduced to one-fourth or one-fifth the normal size. The Graffian follicles were entirely missing. Groups of lutein cells persisted in small numbers, but showed marked hydropic degeneration. Some of the large vessels about the ovary were sclerosed.

g. The liver, kidney, lungs, spleen, and the other organs were examined, but showed no pathological disturbance.

CONTROL GROUP

Pregnant rats of the same stock, the same age and weight, were injected subcutaneously and intravenously with equal amounts of solutions that previously had been strongly radio-active, but were allowed to "decay," until they had lost their radio-activity. These experiments gave absolutely negative results. As a control to the gamma-ray experiments pregnant rats, sisters of the treated animals, were allowed to breed under exactly the same experimental conditions. No abnormal young were observed.

DISCUSSION AND SUMMARY OF RESULTS

It has been shown that when doses of radio-active solutions are injected into an animal marked physiological reactions take place. Large doses produce severe toxemia, resulting in pronounced pathological changes in the various viscera of the white rat (20). A study of metabolic changes in dogs, as determined by urine analysis, showed that following intravenous injections of such solution, there were very decided increases in the total nitrogen content of the urine, the urea, creatinine, uric acid and the total phosphates (22). A prompt reduction occurred in the number of white blood-cells of the dog after intravenous injection of these solutions, associated with a marked decrease in the relative percentage of circulating lymphocytes (23). In order to reduce as much as possible the severity of reaction, very small doses of radio-activity were used in the experiments recorded in this article. But even with comparatively small doses, certain rats treated in utero showed very acute reactions. Many were killed by the treatment and were absorbed or aborted. Others were found

showing pronounced areas of subcutaneous extravasations, mainly situated along the mid-dorsal line of the body and within the meningial sinuses. This condition was probably due to the destructive action of radium on the endothelium of the blood vessels, as well as a possible increase in blood pressure, as was shown to occur in the dog by Burton-Opitz and Meyer (24) after intravenous injections of very small quantities of radium bromide. A similar reaction of the blood vessels to radiation was previously reported by Halkin (25) for the skin of pigs, by Danysz (26) for radiated mice, and later, was again confirmed by Obersteiner (27). This destructive action of radium on the blood vessels is in line with clinical observations on the usual prompt regression of very vascular tumors (the angiomata, in particular) after exposure to irradiation.

The changes in the rat embryos of this experiment are interesting in so far as they show that a sufficient amount of radio-activity was able to pass the placenta and subsequently affect the developing embryo. This occurred after subcutaneous as well as intravenous injections of the mother. By far the most interesting observation concerned the presence of lesions similar to those described above in rat embryos whose mother was treated with radioactive solutions a considerable time *before* mating. The writer has no explanation to account for this phenomenon. It would appear that the treatment of the mother several days previous to conception has lessened the faculty of the later-developing embryo to form proper endothelium of the blood vessels, and the wide distribution of these lesions over the body of the embryo (peculiar to this group of animals) would tend to substantiate this view. One female was injected 22 days before fertilization, and since the solutions lose their radio-activity very rapidly (there is about a 50 per cent reduction in the first hour after the preparation) the likelihood of any radio-activity remaining over during this period and affecting the egg at a later critical moment is remote. The amount of radio-activity remaining after 22 days, if present at all, should, as determined from physical computation, be infinitesimally small.

The series of intravenous injections again emphasize the specific action of radium emanation in the production of typical areas of subcutaneous extravasations in the developing young, and in addition shows that the placenta may act in the nature of a "shock absorber" and prevent the embryo from receiving the full effect of the radiation.

We now come to a consideration of the cases wherein pregnant females were treated with external applications of comparatively large doses of gamma-ray radiation. At this time a report is given only for embryos treated towards the end of pregnancy. The writer plans to continue this line of investigation and treat at earlier prenatal periods.

The results emphasize the well known delayed reaction associated with gamma-ray radiation. There was approximately a ten-day interval following treatment during which no changes were noted in the embryo, and during this period the young animals were born in an apparently normal condition. Acute reactions promptly occurred at the completion of this time, killing half of each litter. The young rats died showing typical radium changes, such as, anemia, diffuse edema and meningial, spinal cord, and subcutaneous extravasations. These extravasations were markedly similar to those already described for the series of solution treatments. The liver in these animals showed a fatty degeneration of the hepatic cells similar to the condition reported by Mills (28) after exposing a series of mice to gamma-ray radiation. The only other pathological change noted in these embryos was a desquamation of the lining cells of the intestinal mucosa. This observation is in line with the results emphasized by Hall and Whipple (29) in their experiments on roentgen-ray intoxication in dogs.

While the animals described above died after showing acute reactions, certain of their litter mates (half of the litter) continued to develop apparently normally. This difference in reaction may possibly be due to individual variability or tolerance for the radiation, but it most likely can be explained by the fact that certain embryos were probably slightly farther away from the source of radiation than others, and as the intensity of radiation varies inversely as the square of the distance, even such slight differences in distances that did exist would be sufficient to subject the embryos to a considerable range in intensity of radiation. This is especially important in this case because the source of radiation was only one centimeter from the body wall of the mother. The quality of radiation, however, remained the same for all the embryos.

It was soon apparent that the animals that lived over the ten day period had not completely escaped the effect of the radiation, as was shown by a suppression of the full development of the eyes. Eye defects were noted, such as opaqueness of the pupil, atrophy of the lens and closing of the lids, which resulted in complete blindness. These animals grew to a normal size, successfully competed with their cage mates for food, and showed absolutely no abnormal neurological condition, except those clearly incident to blindness. At autopsy, in some cases over a year after birth, very decided developmental arrests were noted in the structure of the brain. All grades of such maldevelopment were noted in the condition of the neopallium, from merely a decrease in the size of the hemispheres, which permitted the corpora quadrigemina to be clearly visible from above, to a more marked atrophy of the cerebral cortex until only a very thin lamina of tissue re-

mained to represent that structure, and there were large areas in the frontal, occipital, and temporal region where no cortex existed at all, so that when the meninges were removed the basal ganglia were clearly seen from without.

This correlation between defects in the development of the eye and the brain has been emphasized by Stockard (30) in his recent paper on developmental rate and structural expression. He states as follows: "The periods of arrest necessary to induce the eye and the brain modifications are so close together or so nearly the same, that one generally finds combinations and mixtures of the defects among the same experimental group of embryos." Again in the same article Stockard has shown that the type of deformity that results from experimental disturbance depends upon the developmental moment at which the interruption occurs. It is significant that the animals of this experiment showed arrests in the development of the neopallial portions of the brain and not in those regions which are ontogenically older. Apparently the radium emanation, acting towards the end of pregnancy, had affected the development of the brain *after* the basal ganglia, the cerebellum and medulla had become fairly well differentiated, and therefore these portions showed no gross changes. But the radium had slowed the developmental rate of the neopallium (which we know is one of the last portions of the brain to differentiate) during its period of active cell proliferation, and that portion of the brain was never able to reëstablish its proper rate of development in relation to the other parts of the brain. If the period of treatment had occurred earlier in prenatal existence, other portions of the brain would probably have shown disturbances as well. The writer does not believe that the deformities in the brains of these animals were due to the early production of vascular disturbances later recovered from, but to an actual inhibitory effect of the radiation upon the developing nerve cells. If extravasations had occurred in this group of animals, and were so situated as to affect the development of the cerebral cortex in particular, they probably would have been detected as were even the comparatively small lesions which were associated with the acute reactions. Also, if the effect was largely due to vascular disturbances, from the nature of the radiation employed, one would expect more generalized changes throughout the entire brain. However, on the other hand, Craigie (31), in his recent paper on the relative vascularity of various parts of the central nervous system of the albino rat, suggests that the vascularization of the more recently evolved centers (of the cortex cerebri) is more susceptible than the more ancient regions to sexual, hereditary or environmental influences."

From a neurological point of view, it is interesting to consider that the animals with practically no cerebral cortex reacted so normally in their ordinary behavior. Except for blindness there was no other apparent sensory disturbance, and motor coördination appeared perfect. The physiological functions localized in the cerebral cortex of the rat were in these animals apparently transferred to the basal ganglia and other paleokinetic portions of the brain, showing the remarkable degree of compensation possible to the mammalian brain when the disturbing element acts at an early period in its development. In this connection it is worth mentioning that the radium emanation did not produce a sudden traumatic effect, as is normally the case with the experimental production of brain lesions, and, in fact, the radium changes were probably prolonged over a considerable period. This condition favored the establishment of compensatory reactions, and exists, (as shown by the writer in a recent article (32)) even in the case of radium lesions experimentally produced in adult mammalian brains.

The reproductive system completes its development a considerable time after birth, and so it is not at all surprising that these structures should have shown a considerable amount of atrophy due to the developmental arrest during the prenatal period. The ovaries and testes appeared to suffer with equal severity.

An interesting correlative relation was shown by the fact that the other viscera (digestive, excretory, etc.) of the animals that showed marked developmental arrests of the nervous and reproductive systems were apparently normal, and the animals grew to an average size. The lungs, liver, kidneys, etc. had differentiated before the physical agent was employed. Further studies with earlier prenatal treatments should throw some light on establishing the critical growth periods of the various embryonic structures.

As a final point of interest it is worth considering that the results of this investigation may be of interest to the clinicians and the laboratory workers who handle large quantities of radium and utilize X-rays. Although the results of this paper deal only with irradiation of the female, there is no reason to believe that the germ cells of the male are more resistant to these destructive agents than those of the female, and, in fact, there is very good experimental evidences to show that spermatozoa of some animals are expecially likely to produce abnormal young after exposure to comparatively small quantities of irradiation. Physicians should guard against the possibility of producing developmental arrests such as shown in this

article when treating pregnant women, as well as the possibility of altering the human germ cells by irradiation previous to conception.[3]

Again, the writer wishes to call the attention of those interested in the sterilization by irradiation of the unfit for eugenical purposes, to the need of extensive experimental work on the larger mammals before any such measure be extensively used.

CONCLUSIONS

1. The marked selective action of radium emanation on fast growing embryonic structures was noted in these experiments.

2. Very decided developmental arrests occurred in the differentiation of the nervous and reproductive systems of mammalian embryos exposed to irradiation towards the end of pregnancy.

3. Experimental animals with greatly reduced, or practically no neopallium, gave apparently normal neurological behavior except for blindness.

4. Radium emanation, used either in the form of a radio-active solution injected into the adult female, or employed as an external gamma-ray radiation, produced marked areas of extravasation in the subcutaneous connective tissue of the developing young. This suggests that the action of radium emanation might be selective upon the endothelium of blood vessels.

5. Extravasations occurred in the developing young of females treated with radio-active solutions a considerable time before fertilization, and suggest that in some way the faculty of the later developing embryos to form proper blood vascular endothelium had been interfered with.

6. The results so far obtained indicate that gamma-ray radiation is a physical agent admirably adapted to the study of experimentally produced developmental arrests in mammalian embryos.

7. When women are subjected to therapeutic irradiation, especially during the early stages of pregnancy, the clinician should be forewarned concerning the possibility of producing very grave disturbances in the developing child.

ACKNOWLEDGMENTS

The writer acknowledges with pleasure his indebtedness to Dr. James Ewing for his aid in the interpretation of the pathological results.

[3] The writer does not mean to be understood as stating that present day clinical irradiation treatments produce such effects in the developing young, but it is his personal opinion that such changes are biologically possible. It is not possible to obtain desired information by comparing the amount of exposure that a small mammal can stand with the corresponding dose that a man should tolerate judging by comparative weights. The small mammal can tolerate very much more radiation in proportion to its weight than a man can.

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THE GENETIC SIGNIFICANCE OF THE ALCOHOLIC TREATMENT OF WHITE RATS

E. CARLETON MacDOWELL

Station for Experimental Evolution, Long Island, New York

Even today the lay mind pursues us with the question, "Have you decided yet whether nature or nurture is the great factor?" Yet it is clear that no simple answer is possible for this question. The real problem is not a general comparison of the two factors, but a study of the way each factor operates. After making this study, specific cases may be analyzed. If it is a common error to expect a final victory for either nature or nurture, it is a much more common error to expect a single, simple result from experiments involving alcohol. How far the specific findings herewith reported for white rats may apply to different animals is a matter for experiment, not conjecture; but if one generalization may be permitted, it must be that the action of alcohol on animals is complex, it works through more than one channel, and the end results are due to a balancing of various tendencies. Instead of being on the plane of adding hydrochloric acid to sodium hydroxid and obtaining sodium chlorid and water, experiments with alcohol are more nearly parallel in the complexity of the results, to dropping a bomb upon a whole chemical laboratory. Recognizing the complexity of a problem is one step towards its solution.

The following discussion is based upon experiments carried on for five years at the Cold Spring Harbor Station for Experimental Evolution. Data are at hand showing that alcohol, administered by the inhalation method, tends to modify the treated white rats in three ways: (1) by lowering their growth rate, (2) by reducing their fecundity, (3) by retarding their success in habit formation. The main question under investigation may be stated as follows: does this alcohol treatment have any genetic significance; is the race as well as the individual modified in any way by this treatment? The present experiments appear to give an affirmative answer—the alcohol *has* modified the race. But just how this has been brought about and how to appraise the final results can only be suggested at present. Opposing influences are working: the untreated children and grandchildren of the treated rats produce litters smaller by 10 per cent than their respective controls, and they tend to be less successful in learning

the true path through the maze; yet they grow faster than their controls and they produce from 30 to 50 per cent more litters in the same time. Clearly the effects of the original alcohol treatment are shown in the following generations, but with equal clarity does it appear that these effects are of different sorts.

Primarily it is a matter of finding through what channels alcohol works and not of judging how bad are the results. For to know the *modus operandi* of alcohol is fundamental, while the final results may differ in animals or man according to different superimposed influences. In the rats the criterion of habit formation appears to give evidence that the alcohol has directly modified the germinal material so that a difference in behavior can be detected; this appears in the untreated children and grandchildren, in the treated offspring from treated parents, and in the untreated offspring from treated parents and treated grandparents. A change has occurred that is not removed by the absence of the alcohol, nor is it increased by the application of alcohol to a second generation. But there is no evidence that this modification is located in the chromosomes, or that this will continue to appear through an indefinite number of generations. Litter size gives evidence of the same type of germinal modification—a 10 per cent reduction throughout all generations. Upon growth and the number of litters alcohol must act in a different way. It is probable that the alcohol has not produced a modification at all, as far as these characters are concerned, but rather has eliminated germinal material that bore weaker producing power and slower growth. For, in spite of the marked reductions found in the treated animals, their untreated descendants were superior to their controls in both these regards. Thus there is evidence that alcohol may work in two different ways in the same animals, it may directly change germinal material and it may act as a selective agent. Stockard is about to present evidence of the modifying effect in guinea pigs; Pearl has found evidence of the selective action in fowl. It is then not a case of attempting to reconcile these two results or to decide which is correct; the results are different and both are correct. The two results emphasize two different channels of alcohol action, which, as shown, may occur simultaneously in the same animals. In both of these ways may the race be influenced: it is genetically significant that alcohol may act as a modifier of germinal material; it is genetically significant that alcohol may act as a selective agent between existing germinal differences.

INHERITANCE IN MENTAL DISORDERS

HENRY A. COTTON

Medical Director of the New Jersey State Hospital at Trenton

The entire subject of the rôle of inheritance in mental disorders has been developed largely from a non-biological standpoint, and it was not until the important stimulus of the work of the Eugenics Record Office, under the able direction of Dr. Charles B. Davenport, began to be reflected in the work of various state institutions that any scientific data was obtainable. For years, even centuries, "insanity in the family" was considered the most important factor in the production of a psychosis; later, many of the so-called "hereditary" types were found to be due, largely, if not entirely, to extrinsic factors, and as the importance of these extrinsic factors was demonstrated the hereditary factors lost their importance.

For instance, in paresis, when it was found that the invasion of the brain by the organism of syphilis was the principal, if not the only, cause of the disease, it was not logical or accurate to assume that "mental heredity" could be the cause of the invasion of the brain by the germ of syphilis. Hence, paresis in adults has been quite properly eliminated as a "hereditary disease" although the juvenile type is due to an inheritance of the syphilis germ, or, rather, to a direct transmission of this organism from the mother to the child.

The same theory applies to organic brain diseases in general, such as brain tumor, arteriosclerosis, etc. Those interested in the subject of heredity are quite willing to admit that these disorders depend very little upon the inherited factors.

With the so-called functional mental disorders, the lack of any known extrinsic factors in their causation led one to believe that the inherited factors were most important. This viewpoint was further fortified by the fact that in at least 70 per cent of such disorders heredity was present. As none, except psychogenic factors, were found, it was apparently obvious that the inherited constitution and the unstable personality were responsible for the breaking down of the individual under mental stress. In other words, we were still dealing in these conditions with disorders of the mind and not of the brain.

It is interesting to note that Davenport and others are trying to account for the inheritance of these conditions by inherited disturbances of the endocrin system, a step certainly in the right direction, although as yet no definite proof has been given.

From the study of modern biology we learn what is inherited and what is not. Conklin is very positive in his statements which follow:

> Developed characters, whether acquired or not, are never transmitted by heredity and hereditary constitution of the germ is not changed by changes in such characters. Possibly environmental stimuli, acting upon germ cells at an early stage in their development, may rarely cause changes in their hereditary constitution, but changes produced in somatic cells do not cause corresponding changes in the hereditary constitution of the germ cells. Germ cells, like somatic cells, may undergo modifications which are not hereditary; if starved they may produce stunted individuals, and this effect may last for two or three generations. They may be stained by fat stains and the generation to which they give rise be similarly stained; they may be poisoned by alcohol or modified by temperature and such influence may be carried over to the next generation without becoming hereditary. Environment may profoundly modify individual development, but it does not generally modify heredity.

With these biological tenets before us we certainly should be very cautious in ascribing to heredity the most important rôle in the production of the "functional" psychoses.

As has been stated, the theory of the rôle of heredity in mental disorders was developed largely through statistics dependent upon state hospital records, and anyone who has examined such records is impressed with their inaccuracy and errors. Heredity meant "insanity in the family" whether in the direct or collateral lines, and no investigation was made as to the nature of the psychoses, whether somatic, paretic, etc. From this belief we have happily been led by Davenport to more accurate studies in this field.

At the State Hospital in Trenton an intensive study was made of the hereditary factors in mental disorders, and the investigation was continued for a period of five years. Some 50,000 individuals were charged and as was the case in other hospitals many families were found afflicted with insanity. On the other hand a number of cases, large enough to be conspicuous, were found in which there was no hereditary taint. These so-called negative families seemed to me to be more important that the positive ones.

Further, after carefully studying the material, no laws could be deduced, no inheritance of definite type, but rather a mixed and confusing array of facts which offered little help in solving the problem of the causation of the functional mental disorders. In spite of the obvious evidence in some cases

of the inherited character of these disorders, in a large number of instances the negative cases would loom up in a disconcerting manner and weaken our confidence in the importance of heredity.

In the past five years intensive studies made at the State Hospital in Trenton have convinced me that in these so-called "functional" disorders certain extrinsic factors, formerly overlooked, are of far more importance than the hereditary factors in producing the psychosis. These studies have also confirmed the modern biological axiom that function is directly related to structure.

If this be true, and there is no one today who would doubt such a fact, then abnormal function must be accompanied by abnormal structure. Applying this to the psychoses we are justified in concluding that we are dealing with disorders of the brain, rather than disorders of the mind, independent of the brain. The converse of this law still has adherents, but scientific fact will sooner or later replace such opinions. They are the relic of the belief that the mind was independent of the brain, and such beliefs are contrary to modern biological teaching.

If we have destroyed the rôle of heredity in the production of the psychoses, what are the factors responsible for mental disorders? By utilizing the methods developed in modern medicine we have been able to demonstrate that the so-called "functional" psychoses were accompanied by multiple foci of chronic infections of which the patient was often entirely ignorant, and because of the hidden or masked character of these infections they were entirely overlooked by the physician. This was particularly true of the psychotic patient, for heredity and psychogenic factors were considered the sole agents responsible for the mental disorder.

The doctrine of the rôle of heredity was necessarily fatalistic for if the patient were doomed at birth to have a psychosis why attempt to prevent such a calamity and why make an effort to look for other causes. That such an attitude has existed cannot be denied and it has certainly stifled investigation in purely medical fields. However, it has not hindered the prosecution of studies in the psycho-analytic field.

It has been found that one of the principal causes of these mental disorders was cerebral toxemia arising from the toxemia produced by chronic foci of infection found in the teeth, tonsils, gastro-intestinal tract, genito-urinary tract, etc. I am not prepared to say just what the mechanism is in these cases, whether the poison acts directly upon the brain or indirectly through the endocrin system, but I am of the opinion that with or without heredity these mental disturbances will supervene if the toxin is sufficiently virulent and the individual lacks resistance to the toxin.

It is not my purpose to enter into a discussion of this work except to say that we find that patients suffering from the so-called "functional" mental disorders often have multiple foci of infection and, further, that when these infections are eradicated in the early stages of the disease practically all will recover. As a proof of this statement I will give the results of our work at the State Hospital for the last three years. The spontaneous recoveries for a period of ten years prior to 1918, averaged 37 per cent. In the last three years this recovery rate has been doubled. Further, out of 380 patients in this group, admitted in 1918, only 50 remain in the hospital today and 9 of these are criminals. A recent survey of these cases by fieldworkers has shown that the cases considered recovered are, after three years, perfectly normal and the number of recoveries is larger by ten than at the time of discharge. By that we mean patients discharged improved, who recovered after leaving the hospital.

What place are we then to give heredity in the constellation of causative factors? It certainly cannot be absolutely ignored, but we can still evaluate its importance without giving it the exalted position it formerly occupied.

Does the toxin circulating in the blood of these patients alter or damage the germ plasm, rendering the individual more susceptible to this germ late in life? Are congenital abnormalities of the colon, occasionally found in parent and child, inherited characteristics which predispose to infection late in life, or is the infection carried by the parent transmitted to the child in infancy by direct contact, as in tuberculosis, and does it through years of development produce a psychosis late in life?

These questions are yet to be answered. I believe, however, that the theory of direct inheritance in mental disorders has little to support it at present. As it does not affect the prognosis of a given case its discussion at this time is merely academic.

These views do not in any way diminish the importance of eugenics, but rather open up a broader scope for eugenics in studying how the human race can be benefited. Such studies should not be limited to heredity alone.

COMPARISON OF THE INCIDENCE OF THE SUPRACONDYLOID PROCESS IN GROUPS WITH NORMAL AND ABNORMAL MENTALITY

R. J. TERRY AND LEE D. CADY

Washington University, St. Louis, Missouri

Discrepancy in the incidence of the supracondyloid process as found in different nationalities and in the insane and criminal classes has given rise to the conjecture that, assuming the methods of computation to be comparable, the cause may lie in the physical differences in the different races and classes which have furnished the figures. Thus Wenzel Gruber (1) in St. Petersburg stated the incidence as 2.7 per cent, whereas Testut (2) in Lyons found the frequency to be only 1 per cent; the studies in each case having been made in the dissecting laboratory. Those who have examined the humeri of colored races have expressed the belief that the variation is much rarer than among white peoples, but there no figures for accurate comparison. Nicolas (3) in France, found the process in 6 individuals out of 115 insane subjects, and calculating the incidence on the total number of processes (bilaterality was present in three cases) reached the high percentage of 7.8. A still greater frequency is claimed for Italian criminals by Ferdinando (4) who has given the incidence as 11.29 per cent.

Recently two independent investigations on the incidence of the supracondyloid process have been carried on by the writers, one concerned with a group of people assumed to be normal mentally, the other dealing with the patients of an insane asylum. The results indicate a slightly greater frequency of the variation in the second group but the acceptance of such a conclusion generally is not yet justified, as will appear from the following account of the subjects and methods involved in the calculations.

The study of the so-called normal group was made in the year 1920 (5). One thousand patients in the Dispensary of the Washington University School of Medicine taken at random were examined for the presence of the supracondyloid process by the method of palpation. The group consisted of 683 white subjects of which 316 were males and 368 females; 515 were adults and 168 under age; the remaining 317 were negroes of which 120 were males, 197 females; 248 were 21 years and over and 69 were under age.

In regard to the diagnosis, although there were psychiatric patients in the group none was defined as insane; the great majority came to the clinic on account of some physical ailment incidental to all people. The group is a fair example of the physical and mental status of the poorer class of a large city, suitable for a study in the living of a variation of which our knowledge has been derived from investigation of cadavers of the dissecting laboratory.

The second group was chosen on the basis of mental defect of the subject and consisted of one thousand individuals. These were all patients of the St. Louis Sanitarium, a public institution for the care of the insane. The group was composed entirely of adult white patients, 500 males and 500 females. Regarding the medical diagnoses, an extensive range of mental disorders was included in the examination for the variation.

The method employed for the discovery of the supracondyloid process in the living is very simple: the examiner seated, palpates with the fingers of one hand the arm of the subject who stands before him, while with the other hand grasping the patient's forearm he induces slight passive motion. Recognition of the presence of a process will be favored by its prominence and by the leanness and supplenness of the patient's arm. Processes less than 4 mm. in height are found with difficulty even under favorable conditions and undoubtedly larger processes would be missed in fat or muscular arms. The earlier investigations of the supracondyloid process have afforded abundant evidence that the high development of muscles has no relation to the origin and size of the bony spur, for it may be present at birth, occurs commonly in women as well as in men, and in the left arm apparently as often as in the right. Moreover some of the largest processes have been observed in subjects of frail build and conversely tiny spurs present themselves in robust, muscular arms. When a process was discovered by the method of palpation, X-ray pictures were made to verify the observation and to permit of more detailed study than is possible by the manual exploration, by this means the form, size and location of the apophysis can be determined very accurately.

The value of the combined method of palpation and X-ray had been estimated by comparing the results both in incidence and physical characters, with those gotten by observation of the skeleton and cadaver in the anatomical laboratory. Thus the occurrence of the variation in the mixed group of the Dispensary was represented by 7 persons in 1000; Testut found the variation in 8 subjects out of 929 in his laboratory.

Whereas in the entire dispensary group but 7 individuals presented the supracondyloid variation, in the 1000 insane patients examined at the

Sanitarium, 12 bore the process as revealed by palpation and the X-ray; an incidence of 1.2 per cent as against 0.7 per cent for the normal group. This difference for the entire ground will be somewhat lessened when the comparison is made between only white subjects; the figures would then be 1.2 vs. 0.878 per cent. If the comparison be limited to adult whites, then the difference will very nearly disappear (1.2 vs. 1.16 per cent); but such restriction is not called for in view of the fact already mentioned, that the variation is well known in children even to the new-born.

The mode of distribution relative to sex and symmetry cannot be known until far greater numbers of authenticated data are at hand. There is considerable evidence of the process occurring with about the same frequency in both sexes and in both arms. In the dispensary group there were 4 males and 3 females having variation, whereas in the group of insane there was 1 male and 11 females exhibiting the process. No general conclusion should be drawn from these figures or from tabulations of the distribution with respect to symmetry which in the group at large was 6 for the left and 2 for the right; in the insane 6 left and 7 right.

Diagnosis of the insane patients having the variation revealed one instance each of dementia, hysterical insanity, paranoia and senile dementia; two cases of simple melancholia; two of manic depressive insanity; four instances of dementia praecox. From this it appears that no correlation of the process with a particular type of insanity obtains.

Investigation of inheritance of the variation is in progress for both groups. At the present moment three instances of the process have been found in one family of the dispensary group .

The group from the dispensary has been used for comparison with that of the insane asylum not because it was considered best suited to the purpose but because it comprises the only sort of subjects on which observations have been made and for which figures are available. The intelligent and physically fit element of the population is the last to become available for studies of this nature. However the question raised by the high incidence of the process in the insane given by Nicolas cannot be considered to be answered (even though his group is too small for a satisfactory calculation) until the incidence has been found in a selected number of people vigorous in mind and body. The results of the present comparison certainly do not lend support to the idea of marked frequency of the process in the insane: they indicate only slightly a higher incidence in the insane we have examined.

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THE RELATION OF HEREDITY TO TUBERCULOSIS

PAUL A. LEWIS

From the Henry Phipps Institute of the University of Pennsylvania, Philadelphia

Notwithstanding this subject is very old, one may hope to add some new evidence bearing upon it and to indicate that such conclusions as the profession may possibly have come to are properly subject to revision.

From the beginning of medical time it was considered that tuberculosis ran in families; that heredity had much to do with the occurrence of the disease. With the discovery of the tubercle bacillus and the realization that tuberculosis was due to an infectious agent, it came to be believed that probably hereditary influences were more apparent than real, and that individuals in certain families more often had tuberculosis, not because of any special influence of blood or breeding, but because the disease having been established in that family, the chances for contagion and contact were much increased, and all facts could be explained in the light of our knowledge of tuberculosis as an infectious disease.

Since the establishment of the infectious nature of tuberculosis, a certain amount of work has indicated that possibly there was something more to the matter and that the older view could not be lightly dismissed.

A number of years ago Dr. Pope went over all the material then available at the Saranac Lake Sanatorium, making a tabulation of this material on the basis of relationships of patients, in order to find out whether husband or wife were more liable to contract tuberculosis from each other than were the children of tuberculous parents. This material was collected and taken to England and put into the hands of Pearson who was interested in the study of this kind of material. Pearson applied mathematical methods to the study and seemed to show to his own satisfaction that there was evidence of hereditary influence on the development of tuberculosis in this material, namely, there was certain evidence that the marital relatives contracted tuberculosis in a larger degree than the average population considered without reference to the incidence of tuberculosis in the marriages.

There was also a larger influence evidently due to the blood relationship; that is, the children of tuberculous parents were not only more liable than the average population to have tuberculosis, but were more liable to have tuberculosis than the husbands of tuberculous wives or the wives of tubercu-

lous husbands. There seemed to him a satisfactory evidence that blood had something to do with it. He reasoned that the chances of infection were as great between husband and wife as they were between parent and child. These results of Pearson's, however, have not been generally accepted by medical men up to date, and there are two reasons why this is so. First, from the fact that very few medical men were able to understand the method by which the results were arrived at and the terminology in which they were expressed. The second reason was biological, based on the proposition that most medical men thought that not sufficient account had been taken of the various susceptibilities to tuberculosis as they were here involved, and the fact was disregarded that children were more apt to be infected than adults, and this greater susceptibility to infection during childhood might adequately serve to explain the figures.

A pupil of Pearson's (Goring) undertook to restudy the same sort of material by taking prisoners in a certain English prison as the basis, and again it was found that children of tuberculous prisoners had tuberculosis in an appreciably larger percentage than the children of non-tuberculous prisoners. There was no difference discovered between the wives or husbands, as the case might be, of tuberculous prisoners as against the non-tuberculous. It was reasoned, then, that this had answered the objection cited in a fairly convincing way, because the prisoners are not much in contact with their families, either the marital relatives or the blood relatives, and there was an appreciable difference in favor of the proposition that the incidence of tuberculosis was higher when blood lines were followed. It is difficult to say what impression was made by the work of Pearson and Goring and what the prevailing opinion is in such a matter. Suffice it to say, the influence of heredity as predisposing to tuberculosis has been quite largely discounted by the members of the medical profession and by others whose opinion carried weight in public health work.

A great deal of work done in our laboratory has led us to the conviction that within any species of animal there is a large variation in resistance to tuberculosis. Rats and mice, which as species are very resistant, show a very wide individual variation also. Guinea pigs and rabbits as species are much less resistant, but also show a wide range of individual variation. The records of experiments with cattle indicate similar individual variation, and from what we know of tuberculosis in the human species, we may surmise that there are racial differences, but we may assume with greater assurance that individual susceptibility varies greatly.

We have tried to determine by experiment whether these individual variations had any true basis in heredity. The work has been made possible

by a coöperative arrangement with the Bureau of Animal Industry of the United States Department of Agriculture. Dr. Sewall Wright, of the Bureau's staff, is jointly associated with me in all that follows.

Some fifteen years ago the Bureau of Animal Industry at Washington studied certain problems in the field of genetics and heredity on the basis of experiments on guinea pigs. The problem they studied was: What is the influence of inbreeding on the general qualities of the animal? Does inbreeding, as many stock raisers maintain, inevitably cause deterioration, or does it not? To satisfy themselves on this point, they had started from twenty-three pairs of guinea pigs from which they had continuously bred by a very rigid system of brother and sister mating. The answer which they found was that inbreeding did not, of and by itself, cause deterioration. The primary effect is a fixation of character, good, bad, or indifferent. A different combination became fixed in each family. Families with an especially unfortunate combination did not long survive.

We have used five strains which had been retained from those older experiments to test resistance to tuberculosis. The system of brother-sister mating has been long enough in operation so that the strains are practically homozygous. They are found to differ by as much as 100 per cent in their length of life after standard inoculation with B. Tuberculosis.

The results suggest that the hereditary influence is exerted through at least three and possibly four factors or groups of factors capable of being transmitted separately.

It would certainly throw much light on the fundamental nature of natural immunity to tuberculosis if the physiological characteristics of these hypothetical factors could be determined. Our efforts in this direction have not as yet led to any decisive result. Dr. Wright's study of the Bureau records has shown that such attributes as age, weight, ability to gain weight, fertility, and ability to bring to maturity young born alive are, even when considered together, of slight importance as related to resistance to tuberculosis.

It may possibly turn out that more significance is to be ascribed to the suggestion which a recent experiment has developed, namely, that these guinea pig strains appear to differ in their reaction to a local tuberculous infection of the skin and in their reaction to certain inflammatory irritants, such as croton oil and cantharides. We have not so far been able to formulate an estimate of these differences in terms of resistance factors, and the matter is referred to only to show the trend of our further search for explanatory evidence.

How far is it useful or proper to go in the application of the experimental results so far obtained, to an interpretation of human tuberculosis? It is now generally regarded as true by biologists that wherever factors or groups of factors can be transmitted as units in heredity in one species of either plant or animal, those factors will be similarly under hereditary influences wherever they may occur. It is also recognized that when such factors are found in one species, they are very likely to be common to other related species as among mammals for example. There is, however, no a priori assurance that the relative importance of the factors will be maintained from species to species. There is, then, reason to expect that the factors influencing resistance in the guinea pig are also a human possession; until we can definitely recognize these factors as such and follow them into the human species by observation, we will be unable to dogmatize on their effectiveness as influences governing our racial reaction to tuberculous infection.

THE INHERITANCE OF CANCER IN MICE

LEO LOEB

From the Department of Comparative Pathology of Washington University, St. Louis

We studied the significance of heredity in the etiology of cancer through the long continued observation of a considerable number of strains and families of mice which were kept under identical external conditions, but were bred separately. Our investigations were begun in a preliminary way in 1907 and continued, with the aid of Miss Lathrop, on a much larger scale from 1910 on. Altogether we kept the records of approximately 12,000 female mice which were observed throughout the whole period of their life. The strains were followed through consecutive generations.

The following is a brief summary of our principal conclusions:

1. The cancerrate of each strain or family is a definite characteristic of this strain and is transmitted by heredity to successive generations. The differences in the Tumorrate in various strains are very pronounced; the Tumorrate may vary between zero in certain strains and almost 100 per cent in others.

2. These differences in rate persist with a surprising regularity through successive generations in the majority of strains. In certain strains, however, variations in the Tumorrate do occur. Usually these changes consist in a decrease in the Tumorrate in later generations; they are in all probability due to two factors:

a. In certain families and strains as a result of long continued inbreeding a gradual decrease in fertility and vigor occurs. Associated with this change is, in certain cases, a noticeable decrease in the Tumorrate.

b. Various factors cause a selection to take place within the strains; certain families die out, while others gain preponderance. This change is accompanied in certain cases by a change in Tumorrate.

3. If we cross strains with a similar Tumorrate, the offspring inherits the Tumorrate common to both parents; if both parents differ in Tumorrates, the Tumorrate of the offspring is on the whole intermediate between those of the parents. But all degrees of intermediacy are observed. In our material the number of strains in which the rate of the parent with the higher Tumor-incidence dominated was on the whole greater than the contrary one.

4. The age at which tumors appear is just as characteristic of individual strains as the Tumorrate. The Tumorage is also transmitted by heredity. We can distinguish two factors in the inheritance of the Tumorage:

a. In general in the strains with the higher Tumorrate the Tumors appear at an earlier period of life than in the lower Tumorrate strains. Both Tumorrate and Tumorage are due to the action of an intensity factor. The greater this intensity, the more numerous are the individuals affected and the earlier the Tumors appear in these individuals.

b. In addition to this general intensity factor which applies to many strains, there is a peculiar Tumorage in certain strains which is independent of the Tumorrate. Strains with a similar Tumorrate may have a different Tumorage and in hybrids Tumorrate and age may be inherited separately in the offspring.

5. In general the cancerrate in mice is not a sex-linked character. This fact does however not exclude the possibility that in certain cases a sex-linked factor may enter as one of the multiple factors which determine the inheritance of cancer. Certain of our observations suggest such a possibility.

6. Our investigations make it possible to express in a quantitatively definite manner the hereditary tendency to cancer in individual strains of mice, the figures varying in different strains between zero and 100. This hereditary tendency is, however, not a simple quantity but composite, because, (*a*) The hereditary disposition to cancer is due to the coöperation of multiple factors. The results of hybridization suggest this interpretation.

(*b*) There is hidden in this figure a second factor which again is variable: namely, the activity of the ovary. In all the strains the realization of the hereditary tendency to cancer presupposes the activity of the internal secretion of the ovary. Without this coöperation no cancer can originate. With the full activity of this factor the hereditarily transmitted intensity character determines the upper limit of the cancerrate. Again the intensity of this ovarian factor can be expressed in a quantitative manner, the quantity in this case representing the time during which the ovarian internal secretion had a chance to act. If this secretion is eliminated in mice in the early stages of adult, sexually mature life, mammary cancer is practically prevented from appearing even in normally high tumorrate strains. The longer the ovarian function had a chance to act, the more the cancerrate increases up to the range which is given in the figure for the hereditary tendency to cancer. Suspension of breeding also usually diminishes somewhat the cancerrate, but to a very much less extent than the exclusion of the internal secretion of the ovary which latter is the true realizing factor,

the coöperation of which is necessary. Injury to the mamilla by suckling young can therefore not be an important factor in the causation of mammary cancer in mice.

7. Thus it has become possible to express in a quantitative way the tendency to a disease (cancer) as due to the interaction of two main factors, both internal, the one hereditarily fixed and the other accessible to experimental variation. Both factors combined are the predisposition as well as the cause of cancer. In the case of other kinds of cancer, conditions are presumably similar, the rôle of the ovarian function being probably taken over in such cases by other glands with internal secretion or by external stimulation.

8. Is it possible to associate the hereditary tendency to cancer with other factors active in the life of mice? No definite causal connection between tendency to cancer and such characters as vigor, prolificity, size, color can be found. Connections which may be found are probably not causals but due to coincidence. These other characteristics are inherited just as the tendency to cancer, but are in crosses distributed among the hybrids independently of the predisposition to cancer.

9. There may however possibly be an exception to this independence of the hereditary transmission of the tendency to cancer. If we determine among various strains of mice the mortality or age of death from all other causes except cancer, we find that the high cancerrate strains are very largely strains in which the tendency to die from other causes than cancer at an early period of life is especially pronounced. This connection is presumably not due to coincident but to a causal relationship.

10. The tendency to die from other causes than cancer at a certain period of life is also hereditarily transmitted, but it varies among different strains much less than the predisposition to cancer. Again the tendency to die from other diseases at a certain period of life depends upon the coöperation of the generative organs, but while in the disposition to mammary cancer the internal secretion of the ovary is the main factor and suspension of breeding only subordinate, in the case of resistance to other death producing conditions the suspension of breeding is the main factor and the elimination of the ovarian function is only a subsidiary factor which merely acts through the suspension of breeding which it calls forth. The differences in the tendency to die from other causes than cancer which we find normally between different strains of mice are eliminated in mice which are prevented from breeding. All those strains in which breeding is prevented become approximately equally long lived.

11. As we stated more than 14 years ago, the endemic occurrence of cancer among animals is due to this hereditary transmission of the disposition to cancer. Infection with certain metazoön parasites which stimulate the tissues to proliferation may also play a part. The observations of Fibiger and others suggest this additional conclusion.

12. While these statements apply directly only to animals, the evidence on hand makes it at least probable that in principle conditions are similar in man. Here also in all probability an intensity factor is hereditarily transmitted, which in many cases, however, has been equalized among different families as a result of long continued interbreeding. As to the increase in the cancerrate which seems to be so common an occurrence, we may suggest that as far as it is not due merely to improved diagnosis, it could be referred to a relatively greater frequency in the dominance of the parent with a tendency to a higher Tumorrate in the offspring.

THE INHERITANCE OF A PREDISPOSITION TO CANCER IN MAN

C. C. LITTLE

Carnegie Institution of Washington, Cold Spring Harbor, Long Island, New York

The work of Murray (1908), Haaland, (1908), Tyzzer (1909) and Slye (1913) have shown that a predisposition to the formation of neoplasms is inherited in mice. The exact type of inheritance is still a matter of debate although the weight of evidence points in the direction of a complicated Mendelian inheritance of many factors as the underlying causes. From the outset it should be made clear that inheritance in the direct sense of transmission is not involved. It is rather that certain individuals inherit a tendency towards unbalanced growth, following irritation from either internal or external causes, of various parts of the body. That such a predisposition is inherited in mice is beyond question.

In the case of man there has been from the outset a certain amount of confusion whenever the question of the inheritance of cancer has been discussed. This is largely due to the fact that a direct type of inheritance or transmission was sought for by some investigators while an effort to prove the inheritance of a tendency or predisposition to cancer was the goal of others. There seems to be little doubt that direct transmission of cancer is out of the question. No positive evidence for it can be said to exist. With the matter of a predisposition, however, the case is much more difficult to prove or to disprove. The result has been that pedigrees and statistical data have been advanced as evidence both for and against inheritance and we find well known medical investigators on both sides of the question.

The present investigation aims to analyze statistical data obtained in the family history records of the Eugenics Record Office, Department of Genetics, Carnegie Institution of Washington, and it may be well at the outset to bring out certain points of advantage which it is believed these data possess.

1. They are collected and recorded by that member or those members of any given family whose prime interest is the accurate recording of family traits, both physical and mental. This should be contrasted with the ordinary method of collecting statistics (insurance companies) where a particular individual may or may not be well informed concerning the history of his

family. That is to say, ignorant, illiterate individuals may quite as often be the source of data as are critical and well informed ones. There is, in this case, no previous selection as there is bound to be in the case of the Eugenics Record Office blanks.

2. There is no reason why the data in the Eugenics Record Office blanks should attempt to conceal the incidence of such a biological condition as the occurrence of cancer. Nor is there any reason why an individual should seek to exaggerate its occurrence. This is not true of such statistics as might be collected by Insurance Companies from applicants for policies. It is distinctly to the advantage of an applicant to minimize the occurrence of ailments among his or her ancestors.

3. The information in the Eugenics Record Office blanks is far more extensive; covering a greater family tree than the best insurance company data can possibly be.

4. The opportunity is given to study the incidence of cancer in any generation or group of a family. This is essential for, as I have some years ago pointed out, it is quite possible to have true inheritance of a tendency to cancer and yet little or no available evidence from a statistical point of view if only the relationship of parent to offspring is considered. In other words it is necessary to have available information concerning the sibs of cancerous individuals to supplement and extend the results of analyzing the relation of parent to offspring. In this respect the Eugenics Record Office data are excellent. There are undoubtedly other advantages but those listed above appear to be sufficient to justify an analysis of the Eugenics Record Office data in an attempt to obtain evidence bearing on the inheritance of a predisposition to cancer.

At this point it should be noted clearly that the term cancer is used to include all neoplasmic growths which have caused death. In other words, sarcomas and carcinomas are lumped together, and no effort is made to differentiate between them. This usage is admittedly a popular rather than an exact one, but since all data based on hearsay evidence rather than actual detailed autopsies must be somewhat indefinite in their very nature, a more accurate usage would be equivalent to the use in mathematics of a third or fourth decimal place, when only two were significant.

In order to determine whether or not a hereditary tendency exists, it is necessary to establish an adequate control. In the case of this work, two sets of controls have been used.

a. The table given by Hoffman (Mortality from Cancer throughout the World on the number of deaths from cancer per 100,000 inhabitants in the

United States Registration Area (1903–1912) has been used. This table is divided by sex and age groups as follows:

AGE AT DEATH	MALES		FEMALES	
	Deaths from cancer	Rate per 100,000 population	Deaths from cancer	Rate per 100,000 population
Under 10	1,170	2.5	984	2.2
10–24	2,028	3.1	1,844	2.8
25–34	3,757	9.0	7,891	20.6
35–44	10,750	32.3	26,779	89.0
45–54	24,431	105.4	46,669	222.9
55–64	35,327	257.4	50,393	386.4
65–74	33,745	452.8	43,010	565.7
75 and over	18,381	620.2	24,601	734.1

From it the chance of any individual to die of "cancer" can be directly calculated. In our tabulation, individuals still alive have all been recorded as negative, and have been given their individual values according to their respective age groups and their sex. They represent unfulfilled chances for the production of cancer. In addition the deaths from causes other than "cancer" have been added, thus increasing greatly the difficulty of demonstrating an hereditary influence.

The first group to be considered is composed of fraternities whose father was cancerous and whose mother was normal.

	TOTAL NON-CANCEROUS	TOTAL CANCEROUS	CANCEROUS INDIVIDUALS EXPECTED	EXCESS OF OBSERVED OVER EXPECTED	ODDS AGAINST EXCESS BEING DUE TO CHANCE ALONE
Males.........	939	14 ± 2.50	0.85	13.15	More than 1350:1
Females.......	778	10 ± 2.12	1.05	8.95	215:1
Total.........	1717	24 ± 3.27	1.90	22.10	More than 100,000:1

It will be seen that in each of the three cases, the excess of cancerous individuals among the progeny of cancerous fathers and normal mothers is striking.

A similar result is observed when a tabulation of the immediate progeny of cancerous mothers and non-cancerous fathers is made.

	TOTAL NON-CANCEROUS	TOTAL CANCEROUS	CANCEROUS INDIVIDUALS EXPECTED	EXCESS OF OBSERVED OVER EXPECTED	ODDS AGAINST EXCESS BEING DUE TO CHANCE ALONE
Males.........	553	12 ± 2.33	1.19	10.81	520:1
Females.......	477	27 ± 3.40	1.59	25.41	Over 500,000:1
Total.........	1030	39 ± 4.13	2.78	36.22	Over 1,500,000:1

The final tabulation to be considered is that of fraternities in which at least one cancerous individual appears. If chance alone is operative, there is no reason why the sibs of such cancerous individuals should be cancerous any more frequently than is the population at large. Actually, however, a great excess is obtained.

	TOTAL NON-CANCEROUS	TOTAL CANCEROUS	CANCEROUS INDIVIDUALS EXPECTED	EXCESS OF OBSERVED OVER EXPECTED	ODDS AGAINST EXCESS BEING DUE TO CHANCE ALONE
Total.........	2016	48 ± 4.61	5.80	42.20	Far over 1,500,000:1

From the above three lines of evidence we may conclude that *there exist in man one or more hereditary tendencies to the formation of malignant neoplasms.*

b. The sibs of cancerous individuals can be contrasted with the general population as shown in the Eugenics Record Office data themselves as follows:

	GENERAL POPULATION	SIBS OF CANCEROUS
Non-cancerous..........................	52,499	2016
Cancerous..............................	657	48
Total..................................	53,156	2064
Per cent cancerous.....................	1.23 ± .03	2.32 ± .22

In addition, the progeny of one cancerous parent can be contrasted with the general population from which the families containing the cancerous parent in question has been subtracted. When this is done, the following result is obtained:

General population

Non-cancerous..	44,593
Cancerous..	274
Per cent cancerous...	0.61 ± .02

Immediate progeny of one cancerous parent

Non-cancerous	2,747
Cancerous	63
Per cent cancerous	2.24 ± 0.19

Difference 1.591 ± 0.191 (8.5 times the probable error.)

From both these sources of data it may be concluded that a tendency to the formation of cancer is clearly inherited. The influence of inheritance is shown by the occurrence of a marked excess of "cancerous" individuals over the rate of the general population, in (1) the sibs of "cancerous" individuals, (2) the progeny of "cancerous" mothers by "non-cancerous" fathers; (3) the progeny of "non-cancerous" mothers by "cancerous" fathers.

The *fact* of inheritance is clear, but the *type* of inheritance needs further investigation. It does not appear to be *simple* Mendelian inheritance. This does not however, preclude the possibility that it will be found to be dependent upon multiple Mendelizing factors.

The above findings have little or no direct bearing on the therapy of cancer. They should be simply taken to mean two things. (1) The case of man is closely parallel to that of the laboratory mammals already referred to. (2) If, therefore, the future brings out facts of general biological significance and therapeutic value concerning cancer in laboratory mammals, those facts bid fair, with a small amount of change, to be applicable to humans in at least some degree. Especial attention should therefore be given to the biological investigation of the cancer problem, as a series of growth phenomena, in laboratory mammals. The somewhat tedious question which one frequently hears as to the value of such investigations from a human viewpoint should be, in a large measure unnecessary.

INHERITANCE OF EYE DEFECTS

LUCIEN HOWE

Buffalo, New York

It is only possible here to call attention to a few of the more salient points concerning the subject.

The first is the fact that effects of inheritance are shown in the eye. Everyone recognizes this in its color, position and outward characteristics. But it is also shown in the anatomy and physiology in so many ways and to such a degree as to make the eye practically a pathological museum of inheritance. A table of these inherited characteristics is shown here. A glance at the list shows how many and how varied they are. Anyone who may care to know more of the subject, is referred to a bibliography of hereditary eye defects, compiled by the writer and published a few months ago as bulletin 21 of the Eugenics Record Office of the Carnegie Institution of Washington.

In passing it is worth while to observe that in the curvature of the cornea we have an opportunity to obtain, as perhaps nowhere else, an expression in figures of the degree of exactness of heredity. This is shown in astigmatism. It is well known that this defect consists in a difference in the curvature of the cornea in one meridian as compared with the other. In the ordinary form of astigmatism, the eye is not a globe but is shaped like a rubber ball which has been pressed from above down, or from side to side or at some oblique angle. In other words the radius of curvature in one direction is greater than in the other. Now, we can find the length of each radius by simply placing a suitable lens before the eye when testing the vision. The difference between these two radii may be, for example, not more than a few hundredths of a millimeter and yet that defect is sometimes transmitted from parents to offspring. Not only that, but the relative position of these two axes in the child is sometimes similar to that in the parent Other examples almost as marked as this, could be given if the limits of this paper permitted. The point is that heredity does show itself in many ways of rather unusual interest. The second point to which I would call attention is that the medical profession has until recently contented itself with simply recording the existence of this or that defect in certain families. Some of

these histories, especially those given by Nettleship have been worked out with great care and detail. But during the last half dozen years, ophthalmologists have awakened sufficiently to ask, what shall we consider heredity? Indeed, the terms "filial" and "congenital" and "hereditary" have been so confused as to mean little or nothing. The general conclusion is that the word "filial" should be dropped entirely, because so indefinite. That "congenital" should be used only in its true sense as a trait apparent at birth. So it remains for us to determine the meaning of the word hereditary. By that term we understand ordinarily the appearance of a certain characteristic, occurring more or less frequently in one generation after the other, following more or less closely the Mendelian sequence. But in studying these family histories, one especially has appeared, (and others seem to approach it) in which the number of those affected is so large as to be at variance with all of our former ideas concerning what we have called inheritance. This unusual family was reported by Dr. D. G. Risley, in the *Journal of the American Medical Association* for April 17, 1915. The defect consisted in the absence of part of the iris (coloboma iridis) or, in some, entire absence of that membrane. The unusually large proportion of the defectives was contrary to the law of Mendel or of any one else. The only explanation which can be offered is that the defect may be one of those rather obscure infections which is transmitted in this case by placental circulation or through the germ itself from generation to generation. Naturally one thinks first of a syphilitic infection. There seems no possible reason why that disease should produce a partial or entire absence of the iris—but investigations are now started concerning this point. Since Parodi in 1907 showed that rabbits can be inoculated with the Treponema pallidum, occasional attempts have been made to obtain the eye lesions and then, by breeding, observe the eye changes, if any, in subsequent generations, but a rabbit is here shown which after inoculation, has lost both eyes, and may yet become the sire of other syphilitic rabbits, possibly with partial or total absence of the irides.

But the special object of this paper is, to call attention to a series of experiments which have been made known this year by Professor Michael F. Guyer of the University of Winconsin. A short account of these was published in the Journal of Experimental Zoölogy August 20 of last year, and mention made of them elsewhere.

The statements were in brief that it was possible by serologic methods to so influence the blood supply of a pregnant rabbit that a part of the litter at least, would be born with imperfect eyes, and that similar imperfections could be transmitted from generation to generation. The novelty and im-

portance of that was evident. But in the published statements some details of the process were not described, and the pathological conditions thus transmitted described only as "imperfections," "cataract" and "degeneration." It was with much pleasure therefore that I embraced an opportunity to go to Madison in order to see these pathological conditions as they appeared when viewed with the ophthalmoscope, in a considerable number of these rabbits. The subject proved so interesting and Professor Guyer was so kind in furnishing me with parent stock that I am continuing the breeding experiments.

In order to understand the principles involved it is desirable to recall briefly the reasons and method of the procedure. It has long been known that extracts of certain organs of the body of one animal (A) could be injected into a second animal (B) to a point which we might call saturation or technically, until the second animal was sensitized. Then if the serum of (B) is injected into another specimen of the same kind as (A), that serum from (B) would exercise a certain specific influence upon the organ corresponding to that from which the extract or emulsion was made of the animal (A). This of course is a familiar procedure in serology.

Now the procedure of Guyer was to kill three or four rabbits by placing them in a gas chamber, to extract the lenses, make an emulsion of the lenses and inject that emulsion into a fowl up to the point of full sensitization.

The next step was to inject the serum of that sensitized blood of the fowl into a female rabbit at the time when it would be most apt to effect the eyes of her offspring. Now we know that the point in the head of the foetus which is to become the eye, receives its greatest supply of blood about the twelfth to the fifteenth day after the mating. Therefore after bleeding the sensitized fowl, Guyer injected its serum into the veins of the ear or into a rabbit which he had reason to suppose was pregnant about twelve to fifteen days.

After numerous failures some of the offspring showed decided defects of the eye. Three of these rabbits given to me by Professor Guyer are brought from my small collection in Buffalo for demonstration here. Described in general terms, one has one eye cataractous, the other partly atrophied. The second is practically in a similar condition. The third has only the stump of each eye remaining. They were all born in this condition. The accompanying charts show the lines of heredity in two families. Each individual is numbered.

In order to make sure that the blindness is artificially produced and not the result of breeding from some accidental defect, care was taken with one of these families to obtain original breeding stock from another state. For

when a male with defective eyes is bred to a normal female, the first litter is nearly or entirely normal. But when females of that litter are bred again, to a defective-eyed father, those females produce some defective-eyed offspring. Evidently there is no placental relation between those grandchildren and the defective-eyed grandparents. The daughters of the first generation are merely carriers of the hereditary defect. This is entirely analogous to what we find so constantly in color blindness and some other defects in eyes of the human species. In a short paper of this kind it is impossible and also unnecessary to describe in detail the several structural defects of the eye which seem to be hereditary, especially those visible with the ophthalmoscope, those being interesting only to ophthalmologists.

It is proper however, to observe this selective action of the lens or what Hektoen of Chicago has recently described as the specific precipitin reaction of the lens, is an important factor in these evidences of heredity. Moreover they seem to furnish some corroborative testimony concerning Elschnig's theory of the serological nature of sympathetic ophthalmia. Finally if we could learn the mechanism of the destructive processes it is quite possible that by reversing the method we may obtain a hint at least as to improved forms of treatment of this or other diseases of the eye.

NEW DATA ON THE GENESIS OF TWINS

R. A. FISHER

Rothemsted Experimental Station, Harpenden, England

The subject of the genesis of human twins, apart from its intrinsic interest has a special importance for eugenists. According to the commonly accepted doctrine twins are of two kinds: the so called uniovular or identical twins, which are supposed to have the whole of their heritable nature in common, and the so called biovular or fraternal twins which are supposed to be related genetically no more closely than ordinary brothers and sisters. It is clear that, if this view be correct, human twins provide a test case for measuring the importance of hereditary factors in the determination of human characters. For by measuring the degree of resemblance in any character between identical twins, we might obtain an upper limit for the effects of heredity, while by comparing the resemblance of fraternal twins, with that known to exist between ordinary brothers and sisters, we might measure the effects of early environment and especially of intrauterine environment. The importance of human twins as a test case for eugenics was appreciated by Galton, and since the publication of his work, the conclusions at which he arrived have been repeatedly quoted by other writers.

Current opinion generally accepts the division of twins into the two classes distinguished above, classes both of which have analogues in the animal kingdom. Great disparity of opinion exists, however, as to the frequency with which these two classes occur. Some biologists believe that identical twins are relatively frequent. Extensive statistics show that twins of unlike sex occur in about 3 cases out of 8; and if we argue that of the fraternal twins nearly 50 per cent must be of unlike sex while all identical twins must be of like sex, we are led to the conclusion that about one pair of twins in 4, must be an identical pair. Others, however, ignoring the distribution of sex, believe that identical twins are excessively rare. It is generally believed that the two types of twins may be distinguished by an examination of the fetal membranes, but the proportions arrived at in this way by gynecologists are excessively divergent, and according to Davenport, twins of unlike sex are frequently reported to be uniovular in contradiction of the current theory.

The only extensive body of measurements of twins was taken by Thorndike, and published sixteen years ago. It is not sufficiently recognized that his results are clearly inconsistent with both of the views currently held. The 50 pairs of twins observed by Thorndike do not fall into two distinct groups, but show themselves on examination to be a single homogeneous group. The most delicate tests prove that those pairs of twins most like in any one trait, are not more alike than others in other traits. The whole group arises apparently from a single mode of genesis; and those of unlike sex are not sensibly less alike than those of like sex. If we adhere to the theory of the dual origin of human twins, we must conclude from Thorndike's data either, that (1) all or nearly all the twins examined were "fraternal," in spite of the facts (*a*) that the proportion of like sex is much greater than 0.5, and (*b*) that the level of resemblance in all traits is much higher than that found between brothers and sisters, or (2) that all or nearly all were "identical" in spite of the facts (*a*) that 9 pairs were of unlike sex, and (*b*) that the general level of resemblance is considerably less than we should, for other reasons, expect between genetically identical individuals; for example, several pairs differ considerably in eye color and hair color.

For these reasons, after a statistical examination of Thorndike's data, I have brought forward (Genetics, 4, 489, 499, September, 1919) the tentative suggestion that the ordinary mode of genesis of human twins is intermediate in character between the fraternal and identical modes of genesis, and in particular that while the maternal inheritance is identical, the twins being derived from a common ovum, the paternal inheritance is merely fraternal, the twins being derived from different spermatozoa.

The purpose of the present note is to present such new data as I have been able to collect in testing this particular suggestion.

Children of the same parents may differ in a Mendelian factor, if either or both of the parents are heterozygous; these differences will be apparent if neither parent is a homozygous dominant. To make clear how the suggestion may be tested, the following table shows the parentage of unlike twins produced, on each of the possible modes of genesis, according as the mother, the father, or both parents are heterozygous.

	MOTHER HETEROZYGOUS	FATHER HETEROZYGOUS	BOTH PARENTS HETEROZYGOUS
Fraternal	50	50	37.5
Semi-identical	0	50	25.0
Identical	0	0	0

It is apparent from this table that if twins are readily produced in the manner here tentatively suggested, we may lay down the rule, which should be capable of definite proof or disproof, that all twins unlike in any Mendelian factor, have fathers heterozygous in that factor.

The most suitable factor to choose for carrying out this test would seem to be eye color; for although recent observations have thrown doubt upon the simplicity of the inheritance of yellow pigment on the iris, it appears in the majority of stocks to be inherited as a simple dominant. Valuable cases also occur occasionally in some rare defects, which are known to be due to simple Mendelian factors; of these a number of cases are on record in which albinism appears in one twin and not in the other. The cases which I have hitherto obtained in which twins have been observed to differ in what is believed to be a simple Mendelian factor, are set out below:

	FATHER HETEROZYGOUS	FATHER HOMOZYGOUS
Albinism	4	0
Eye color	2	0
Other cases	2	0
Total	8	0

It will be seen that no case has as yet come to light in which the father is homozygous; cases in which both parents are heterozygous have not here been recorded, so that on the current theory we should expect to find the father homozygous in one-half of the cases.

The above numbers are far from conclusive, and have been put forward to show that the subject should be thoroughly investigated. We hope that this may be done in London, where over a thousand pairs of twins could rapidly be obtained; but at present the work is delayed for lack of funds. In the second place, it should be possible quickly to ascertain whether or not the father of unlike twins is always heterozygous. One hundred accurately recorded cases should settle the whole question; of course out of a hundred cases we must expect a certain number of exceptions owing to wrongly ascribed paternity, but in such a number it would be amply clear, whether or no there were a real difference between the paternal and the maternal inheritance of twins.

MAIN RESULTS OF A STATISTICAL INVESTIGATION OF FINGER PRINTS FROM 24,518 INDIVIDUALS

KRISTINE BONNEVIE

Institute of Genetics, Kristiania

As our knowledge of human inheritance proceeds it will on various points be taken into the service also of the court of justice, especially in questions about paternity. The cases are, however, as yet very few in which a decisive proof of paternity could be afforded through investigation of hereditary characters of persons in question (see Mohr 1921).

The number of requests from lawyers for a hereditary investigation of their clients is nevertheless rapidly growing, and therefore it would be of importance for experts to know the law of inheritance of a series of external human characters, as a basis of their decision of whether or not these characters might be used for a statement of relationship between two persons.

It is but natural that a character like that of the "finger prints" which has already performed so important services in questions of identification, should come in the first row also in an investigation of inheritable characters. And there exist indeed, already several indications of the heredity of general types of patterns on both hands and feet, even if the details of these patterns always have been shown to be characteristic of a single person only.

Our modern knowledge about the patterns formed by papillary ridges on the fingers of man is founded above all upon the results of Galton laid down in a series of papers among which his book on "Finger Prints," 1892, should be mentioned in the first row. A voluminous literature, contributions to which have been given from many different countries, has followed the publications of Galton. Of special interest are the papers by Whipple (1904), by Schlaginhaufen (1905–1906) and by Wilder (1916), the two last named papers containing also full lists of the literature upon this subject.

With regard to the *heredity of papillary patterns* Galton has in his famous book on "Finger Prints" (1892) already treated the question in a chapter containing a very valuable material. Through a statistical treatment of the finger patterns of 150 fraternal couplets, further through an investiga-

tion of 17 sets of twins and finally also through a comparison of children with their parents in cases in which both parents were "like patterned"—Galton has reached a conclusion expressed in the following words (p. 189): "The decided tendency to hereditary transmission cannot be gainsaid in the face of these results, but the number of cases is too few to justify quantitative conclusions."

More conclusive evidence is given by Wilder (1916, 1919), although his attention has been directed more on palm and sole patterns than on those of the fingers.

His results are reached through an investigation partly upon the hands and feet of twins, partly also upon whole families.

The papillary patterns of the fingers have, however, not yet been subject to special investigations with regard to their heredity. And before this question can be definitely solved it will be necessary to settle a series of other questions with regard to the statistical occurrence of the different types of patterns upon each of the fingers, to the correspondence between different fingers and also to the symmetry between the fingers of the right and the left hands with regard to their types of pattern.

Without knowledge about these facts one will have no real base for a sound criticism of the results of family investigations.

Galton (1892) has, upon this point also, made the beginning through a universal statistical treatment of the finger-patterns of 500 individuals. His results which on many points seem extraordinary but which have in the main lines been stated through my investigation will be treated together with the results of the latter.

The statistics of this paper (tables 1 and 2) are based upon the material of The Office of Identification of Kristiania, which by its Director was very kindly offered at my disposal. The finger prints of this office are taken from 24,518 individuals and counting, therefore 10 times this number of fingers. It is classified according to the scheme generally adopted for an identification of criminals (see Henry 1901), according to the *type* of pattern on each finger on both hands.

Three types of patterns are known as *whorls*, *loops* and *arches*.

The *whorls* are characterized through the existence of *two deltas*, that is on each side of the pattern one ridge dichotomously divided forming a triradius so as to embrace the central part of the pattern, in which the ridges may be circular, forming a single or a double spiral or even other more irregular figures.

In the *loops* there is only *one delta* while one or more ridges are forming loops opening towards the side of the finger opposite to that of the delta.

The loops may open towards the radial or towards the ulnar side of each finger and according to this they will in this paper be called *radial* or *ulnar* loops.

The *arches* represent the simplest patterns, the ridges here running in more or less deep bows from side to side of the finger without making any backward turn or twist. There is *no real delta* in the arch.

As already mentioned, the statistics of this paper are based upon 24,518 individuals, or a number of 245,180 fingers. The formulæ of all individuals have been dissolved so as to give the type of every single finger and after this the number of fingers with one and the same type has been counted for application and combination in different ways.

It is seen from table 1 that the three types of finger-patterns are very unlike with regard to their numerical appearance within the whole material (245,180 fingers), the *whorls* (62,883) appearing in a percentage of 25.65, the *loops* (164,150) in 66.95 per cent, while the percentage of *arches* (18,147) is only 7.4. Such a difference proved in a material large enough to exclude every influence of chance, at once indicates that the finger-patterns in their occurrence are under the control of some constitutional law.

In table 1 we find also a conspicuous difference in the occurrence of *radial* and *ulnar* loops, the latter appearing in a percentage of 61.14 of the number of fingers, while the percentage of radial loops is only 5.81.

The distribution of pattern-types between right and left hands also proves to be peculiar, the whorls being considerably more numerous on right hands (29.38 per cent against 21.92 per cent on left hands), while arches (6.92 per cent to 7.88 per cent) and especially also loops (63.70 per cent to 70.2 per cent) are more richly represented on left hands. This difference is, within the loops, due to the ulnar loops only (57.76 per cent to 64.52 per cent) while the occurrence of radial loops (5.94 per cent to 5.68 per cent) is practically the same on both sides.

The above statistics refer to the whole material of fingers taken together. The picture here given is very much deepened through a consideration also of each finger separately.

It is from the figures of each horizontal line (table 1) evident that digits I–V all have their special characteristics with regard to the statistical occurrence of the pattern-types.

Very obvious is the general similarity between *digits I and IV*, both having a very *high percentage of whorls* especially upon right hands, and both having also a very *low number of radial loops*, while *ulnar loops* and *arches* also show values considerably *below the average* especially on right hands.

TABLE 1

Fingers	Hands	% of fingers: Whorls	Loops: rad.	Loops: uln.	Loops: Sum total	Arches	
All	both	25,65	5,81	61,14	66,95	7,40	100,00
	right	29,38	5,94	57,76	63,70	6,92	100,00
	left	21,92	5,68	64,52	70,20	7,88	100.00
1st	both	35,04	0,34	60,71	61,05	3,91	100,00
	right	41,66	0,36	55,37	55,73	2,61	100,00
	left	28,42	0,31	66,05	66,36	5,22	100,00
2nd	both	28,81	23,98	30,66	54,64	16,47	100,00
	right	29,67	25,73	27,51	53,24	17,09	100,00
	left	28,10	22,24	33,81	56,05	15,85	100,00
3rd	both	16,22	2,31	70,44	72,75	11,03	100,00
	right	16,88	2,22	70,91	73,13	9,99	100,00
	left	15,55	2,40	69,98	72,38	12,07	100,00
4th	both	37,10	0,78	58,71	59,49	3,41	100,00
	right	44,98	1,21	50,74	51,95	3,07	100,00
	left	29,22	0,35	66,68	67,03	3,75	100,00
5th	both	11,01	1,64	85,18	86,82	2,17	100,00
	right	13,72	0,17	84,26	84,43	1,85	100,00
	left	8,30	3,10	86,10	89,20	2,50	100,00

Digit II gives a picture very different from the one here mentioned. *Whorls* are occurring in a percentage somewhat above the average but very equally distributed on right and left hands; this approximate statistical correspondence between digit II of right and left hands is valid also for the other patterns.

But the most striking feature in the characteristics of digit II is that of the *exceedingly high percentage of radial loops* and also of *arches*, both pattern-types somewhat, but not very much, more numerous on right hands. The *ulnar loops*, in return, are occurring in a percentage *far below the average*.

Digit III shows a relatively low number of *whorls* and a high one of *ulnar loops*, while *radial loops* give values below the average for this pattern. *Arches* appear, also here, remarkably frequently even if their values are considerably below those of digit II.

Digit V finally, has high numbers of *ulnar loops* only, and low percentages of all other patterns. But even here some peculiarities of their distribution should be noted, namely the very considerable *surplus of whorls upon right hands* as compared with the left ones,—and also the peculiar occurrence of *radial loops*. Their percentage of occurrence is below the average although higher than that of digits I and IV, but their distribution upon right and left hands is very unlike radial loops scarcely occurring on digit V of right hands but in a percentage higher than all other fingers except digit II on the left hands.

The characteristics of the various fingers as now studied on table 1 receives an interesting supplement through a look also at table 2, showing the statistical distribution of each pattern type; their occurrence on the fingers is here given in *percentage of the absolute number of the type* contained in the whole material. The average number upon each of the 10 fingers would then, of course, be exactly 10 per cent of each type.

The *whorls* are distributed with high ratios upon digits I and IV of right hands and with low ones upon digits III and V of both hands, while upon the fingers not here mentioned their occurrence is little above the average.

The *radial loops* are very particular in their distribution, more than four-fifths of all of them being found on digit II, the right hand with the highest percentage. On all other fingers radial loops are very rare, the lowest percentage being found on digit V of right hands, while the same finger of left hands has a number of radial loops higher than that of digits I, III and IV.

Ulnar loops show, in return, upon digit II an occurrence far below the average, while on digits III and V it is rising above this point; upon digits I and IV the percentages of ulnar loops give very near average values.

TABLE 2

Pattern type		% of the type												
		All fingers		1st finger		2nd finger		3rd finger		4th finger		5th finger		
		right	left	right	left	right	left	right	left	right	left	right	left	
Whorls		57,27%	42,73%	16,24%	11,08%	11.57%	10.96%	6.58%	6.06%	17.53%	11.39%	5.35%	3,24%	100.00
		100%		27,32%		22.53%		12.64%		28.93%		8,58%		100.00
Loops	rad	51,10	48.9	0,62	0,53	44,29	38,28	3.82	4,14	2,08	0.62	0.29	5.33	100.00
		100		1,15		82.57		7.96		2,70		5.62		100.00
	uln	47,24	52,76	9,06	10,80	4.50	5,53	11.60	11,45	8.30	10.90	13.78	14.08	100.00
		100		19,86		10,03		23.05		19.20		27.86		100.00
	Sum total	47,57	52,43	8,32	9,92	7,96	8.37	10.92	10.81	7,76	10,01	12,61	13,32	100.00
		100		18,24		16.33		21,73		17.77		25,93		100.00
Arches		46,77	53,23	3,53	7,05	23,09	21,41	13,50	16.31	4.15	5.08	2,50	3.38	100 00
		100		10,58		44.50		29.81		9.23		5,88		100.00

The *arches* finally, like the radial loops, have their highest values on digit II, nearly one half of all arches occurring on this finger. But also on digit III we find arches richly represented, and then in sinking values upon digit I, IV and V.

Many questions arise through an attentive consideration of the figures on tables 1 and 2. Above all, however, answers are wanted to the following questions:

Which are the reasons of:

1. The general statistic similarity between the *first* finger and the *fourth?*

2. The great *frequency of whorls* upon the fingers just mentioned as well as the very *striking surplus* of their percentage *upon the right hands*, a feature which is visible on all fingers but especially valid also for digit V?

3. The peculiarities of the *second* finger, viz. (*a*) the surprisingly high percentage of *radial loops*, with a considerable surplus upon right hands; and (*b*) the high value also of the percentage of *arches*.

4. The relatively high percentage of arches and, less so, of radial loops upon the third finger?

5. The strange difference between right and left hands with regard to *radial loops* upon *digit V*, their value on the left side being more than 18 times that of the right.

The answers of these questions can certainly not yet be given, and even a thorough discussion of them would lie outside the scope of this paper. A few words may be mentioned, however, with regard to the directions in which the answers might be sought.

The existence of papillary patterns on the human palms and soles has, as before mentioned, in full agreement been explained *phylogenetically* as a remainder from patterns on the elevated pads of early ancestors, especially among prosimia and marsupialia (Klaatsch, 1887–1888; Whipple 1904; Schlaginhaufen, 1905; Wilder 1916).

With regard to their *function* two different theories have been maintained, the one (Whipple) considering the papillary patterns as organs of a *mechanical* use ("friction-ridges"), the other theory attaching more importance to the *sensory* function of the ridges ("Figure tactiles" Schlaginhaufen), both theories agreeing, however, in the conclusion that the function of papillary patterns is best fulfilled, when the direction of their ridges is one vertical to the direction of pressure against the object to be touched.

When trying to answer the questions above raised, one has then to consider the interaction between two different forces, the one *conservative*, preserving phylogenetically older conditions, the other force *adaptive*,

changing these conditions according to the function of each finger. A correct understanding of the effects of these two causes will be of decisive importance also to the whole question about heredity of finger-patterns.

The peculiarities with regard to the statistical occurrence of pattern-types may be divided into two groups, those regarding the whorls upon digits I and IV (question 1–2) and on the other side those of the radial loops and arches upon digits II–III (question 3–4). The peculiarities of digit V will enter partly into the first and partly into the second of these groups.

Considering the *first group* of questions, the similarity between digit I and digit IV and the very frequent occurrence of whorls especially on these fingers of right hands, it seems evident that the causes of these peculiarities should be sought before all in the phylogeny of patterns. A functional adaptation is, that is true, easily imagined for the first finger with its manyfold use, but an explanation of this kind will scarcely go for the fourth finger, which on the human hand, is perhaps less active than any of the other fingers. In this finger, therefore, phylogenetically old characters may especially have been preserved and if similar conditions are found in the first finger the same explanation should probably also be found valid for both fingers.

With regard to the phylogeny of pattern-types Wilder (1916), basing on the investigations of Whipple (1904), maintains that the patterns of human hands represent (p. 235) "every stage in the process of development, from a whorl of concentric lines with a definite number of embracing triradii, to a condition in which core and triradii are completely lost and the surface is covered by simple parallel ridges, straight or slightly curved." And further also that "from comparative study of other primates it is plain that the course of evolution has been from the involved condition the whorl, which is distinctly simian, through every stage in the reduction of the pattern, to its final complete effacement."

If this be true, it is of great interest to find the *whorl*, as the phylogenetically oldest pattern, so richly represented on the fourth finger. One must only ask why this peculiarity of the fourth finger should be found so nearly repeated in the patterns also of the first?

Without having made any investigations upon this point myself, I can again only look at the statistic facts of my tables in light of the results already reached by the investigators mentioned. All these authors agree in the consideration of the papillary patterns as reminiscences of elevated pads in the ancestors, the same elevated pads which are found also in human embryos and young children (Johnson, 1899, Retzius, 1904), and therefore also as indications (Whipple, 1904, p. 332) "that at the same time when

ridges first developed in that region the pad had the elevated form of the typical walking pad." Miss Whipple continues: "The second principle is that the relative constancy of occurrence of the typical pattern in a species or a group of related species, may be used as a criterion for determining the relative length of time during which various pads were retained in their typical form."

The same principle being made valid also for the various fingers of one species *the pads of human ancestors should be supposed to have existed longer upon the first and the fourth finger than upon any of the others.*

This is of interest in view of the fact that just among prosimians and marsupialias, the mammal groups which are supposed to be most nearly related to the row of human ancestors, many examples are found of a high development of the *fourth* finger, this finger being *together with the first* used by the climbing species for grasping round branches of trees.

But there is also another feature of the statistics regarding whorls on digits I and IV which needs an explanation, viz., that of *the great surplus of whorls on right hands.* If the principle of Whipple, just mentioned, is applied also here, then the conclusion would be that *the elevated pads* of first and fourth fingers *should have existed longer upon the right hands than upon the left ones.* This conclusion should, in case, be made valid also for *digit V*, in which there is an equally great surplus of whorls on right hands.

Personally I have no real base for taking a standpoint to the conclusions here drawn. They are logical consequences, however, of the theories maintained by Whipple as well as by Wilder and based upon the results also of Schlaginhaufen with regard to the phylogeny of finger-patterns.

A difference between the first finger and the fourth with regard to the statistical appearance of whorls, these being more numerous (44.98 per cent of the fingers) upon digit IV of right hands than upon digit I (41.66 per cent), may be an expression only of the more conservative conditions of the fourth finger.

The *second group* of questions, regarding the peculiarities of digits II and III, contains problems of a very different nature. Here we must look for the answers not so much in the phylogeny of patterns as rather in the physiology of these special fingers. No other finger of the human hand is of a use so varied and extensive as just digit II and also the third finger very often partakes of its task in a position opposed to digit I. The high percentage of *radial loops* and of *arches* on digits II and III, therefore, may *a priori* be looked upon as a phenomenon of adaptation, and also here the results of previous investigators are in a remarkable way supported by the statistical facts.

As already mentioned both existing theories upon the function of papillary ridges maintain that the direction of the ridges ought to cross the line of greatest pressure. And the tactile theory maintains further, based upon experiment that the sensory effect of two parallel ridges is greater when both belong to one and the same loop than when they are independent of each other (Féré, 1895; Schlaginhaufen, 1905).

Remembering the position of the second finger when working alone in opposition to the first one, it seems evident that the *radial* side of digit II and its papillary pattern should be of great importance, whether the function of those lines be of a mechanical or of a sensory nature. Among the different pattern-types, therefore, the *ulnar loops* will be the ones least useful, their ridges running away from the radial side of the finger. *Whorls* and *arches*, the peripheral ridges of which patterns are running out parallel on both sides of the finger, seem here to be of equal use as compared with each other. But no other pattern would for the special use of the second finger make better service than the *radial loops*, the ridges of the radial side of the finger here being combined into pairs as arms of one and the same loop.

This consideration of the functional importance of different papillary patterns agrees exceedingly well with their statistical distribution upon the second finger. The number of *ulnar loops* is here very considerably lower than upon any other finger, making (table 1) only 30.66 per cent of the number of fingers while 58.71 per cent (digit IV) is the lowest value upon other fingers. As shown in table 2, 4 to 5 per cent only of all ulnar loops are found on the second fingers of right and left hands instead of the average 10 per cent. The *whorls* give values not far above the average while *arches* and especially also *radial loops* are represented in extraordinarily high numbers, 44.5 per cent of all arches and 82.57 per cent of all radial loops being found upon second fingers only (table 2).

Although the statistical difference of pattern-types between right and left hands is considerably less evident on the second finger than on digits I, IV and V, it is interesting to note that also here a difference exists, the functionally most effective patterns (radial loops and arches) showing a considerable surplus on right hands. A parallel to this phenomenon is shown by Wilder (1916) to exist with regard to the formula of the human palm, the functionally most advanced configuration being considerably more richly represented on right than on left hands. Wilder draws in the same paper the conclusion (p. 236) "that this result has been gained since the adaption of right-handedness."

What has been said here about digit II is valid, to a certain degree, also with regard to the *third* finger. Also here we find the finger engaging its

radial side when working together with digit II, opposed to digit I, and also here we find the percentage of *arches* considerably above the average (11.03 per cent to the average 7.4 per cent, table 2). The *radial loops*, however, so peculiar to the second finger, are here not strongly represented (2.31 per cent of the fingers), even if more so than on digits IV and V.

A few words should be said also with regard to *digit V*, agreeing with the first named group of fingers (digits I and IV) in the great surplus of *whorls* on right hands (13.72 per cent of the fingers) as compared with the left hands (8.30 per cent),—and at the same time entering into the second group (digits II and III) on behalf of a peculiarity in the occurrence of *radial loops*.

If the explanation given for the statistics of whorls upon digits I and IV shall prove to be correct, then the same reference to the phylogeny of finger-patterns will be valid also here. The great difference in the number of whorls on right and left side would, therefore, according to Whipple (1904) indicate that the inflation of the elevated pads developed more rapidly on the left side. Upon this side, therefore, the reduction of the original finger-pattern, the whorl, has set in earlier and the number of other patterns, loops and arches is higher on left hands (tables 1 to 3). It is at first glance surprising that the number of *radial loops* upon digit V (5.62 per cent of all radial loops) should be so much higher than those of digit I (1.15 per cent) and digit IV (2.70 per cent). But it is, for example, by grasping round a ball, very easy to state that even if the use of digit V is upon the whole very restricted, its radial side is the one generally used. The peculiar difference between right and left hands with regard to the occurrence of radial loops upon digit V, 0.29 per cent and 5.33 per cent respectively, stands as a fact the explanation of which should be sought through future investigations.

The statistical facts now being analyzed, we may turn to the conclusions which will be of direct importance to a hereditary treatment of a material of finger patterns.

Many cases may be demonstrated which at first glance seem to prove that heredity plays an important part in the distribution of pattern-types. A critical survey of these cases in light of the statistical results shows, however, that their value as proofs of heredity is very different. A few examples from the material at my disposal will illustrate this.

Experiment 1. Two brothers are found with ulnar loops on all fingers of both hands. The pattern-formula of this example occurs in 4.29 per cent of all individuals, that is: Among each 50 persons, at least 2 should be expected to have this formula. The occurrence of two such brothers, therefore, cannot be considered as a proof of heredity.

Experiment 2. Two brothers have arches on all fingers of both hands. Arches on all fingers of both hands is a very rare occurrence found in no more than 0.18 per cent of individuals, that is: more than 1100 persons would be necessary to statistically secure the presence of 2 individuals with the formula mentioned. Its occurrence in two brothers, therefore, must be considered a very strong indication of heredity.

Experiment 3. Three brothers have all a radial loop on the second finger of their right hands and ulnar loops on all other fingers. A radial loop on digit II of the right hand occurs in 25.73 per cent of individuals, ulnar loops on all fingers of one hand in 14.29 per cent. Even if I cannot tell the exact percentage of the occurrence of a formula like that of the example it is, therefore, quite sure that such a formula is not at all rare. Among a hundred persons we might easily happen to find three with finger patterns like those of the brothers mentioned, and they will, therefore, give no definite answer in questions about heredity.

The examples here mentioned will suffice to show that hereditary investigations upon finger-patterns should comprehend first of all a critical survey of the material, basing on the statistical occurrence of each pattern upon different fingers. If in this complicated matter clear results shall ever be reached, the work ought to begin with patterns of a relatively rare occurrence, as *arches* or *radial loops*.

Besides the statistical data the influences of the phylogeny as well as of the physiology of finger-patterns should be considered in order to get a real understanding of the constitutional forces working in their heredity.

Basing upon Whipple's theory of the whorls as the typical pattern of elevated pads, a theory which, as mentioned above, has got a strong support in some of the statistical results, and of the other patterns as a series of reduction stages from the whorls, our results with regard to the patterns of human fingers will be the following:

All fingers considered as a whole, we may look upon *the ulnar loops* as the typical human pattern, occurring on two thirds of all fingers and filling the place wherever this is not, for special reasons, occupied by other patterns. These reasons may be of two different kinds, *conservative forces* having preserved the phylogenetic oldest pattern, the *whorl*, in a certain percentage on all fingers but especially upon digits I and IV, and always more so upon the right hand than upon the left,—and on the other side *adaptive forces* influencing the reduction process of the pattern in correspondence with the function of each special finger, thus producing *arches* and *radial loops* upon the fingers in which the radial side is of special importance to their function; this is shown to be the case with digit V and III and, much more so, with the digit II.

With regard to all pattern-types there is found a more or less conspicuous difference between right and left hands, the phylogenetically oldest patterns, the *whorls* being preserved in a higher percentage on right hands, especially on digits I, IV and V; and the younger, adaptive patterns, *arches* and *radial loops* being also more numerous on the right second finger than on the left.

Phenomena of this kind may serve as a support of the assumption of Wilder (1916, p. 236) of an early adaptation of the right-handedness; it should, for an explanation the statistical facts mentioned, be supposed to have existed *before* the full inflation of the elevated pads upon digits I, IV and V, as well as before the present development of the adaptive patterns of digit II.

Assuming that the different pattern-types which "are first seen in an embryo of approximately four months, since which age there is no indication of change throughout life" (Wilder, 1916, p. 235), are determined through hereditary factors, a phylogenetic development from whorls into loops and arches may have been performed in two different ways, either through *a loss of some factor determining the triradii* of the whorls, or through the *acquirement of new factors checking their development.* A contrast should, in both alternatives, exist between individuals with their original, typical patterns practically intact, that is: with whorls on all fingers, and others in which the whorls are absolutely lost, and between these two extremes a series of transition stages.

The heredity of the different stages of a gradual phylogenetic reduction of the whorl into less complicated patterns presents in itself, no special difficulty to the understanding. A great difficulty arises, however, when one thinks of the adaptive results reached especially on the second finger through this reduction, an adaptation equally well fitting both a mechanical and a tactile function of the papillary ridges. As already mentioned by Wilder (1916, pp. 234–237) the adaptation of finger-patterns to their function is so much more peculiar, as the patterns themselves during individual life are not at all influenced by either age or function or other external forces. The pattern-types are determined long before birth, and cases like that of the two brothers with arches on all fingers (experiment 2, p. 209) strongly indicate that the determination is lying in the germ-cells. How, then, are these adaptive results reached?

I can here only ask the question, and give no answer. But the answer once given, will be one of general importance applying also to phenomena of adaptation upon other and more important fields than that of finger-patterns.

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THE GENETICS OF FECUNDITY IN THE DOMESTIC HEN

C. C. HURST

Burbage, Leicestershire, England

Five years' experimental breeding on Mendelian lines from 1910 to 1916 gave results which show that the fecundity of a hen depends on the combined action and reaction of many genetic factors.

Seven main genetic factors have so far been identified in the experiments. Five of these, E, W, S, M, and H, influence fecundity, one affects egg-size (N) and one egg-color (C). Of the five factors influencing fecundity E and W together determine winter-production, S is manifested in spring-production, M influences autumn production, while H affects the production of any of the three periods.

The seven pairs of Mendelian factors are as follows:

E	e	Early and late sexual maturity of pullets.
W	w	Fast and slow rate of winter production.
S	s	Fast and slow rate of spring production.
M	m	Slow and fast rate of autumn production.
H	h	Broody and non-broody instinct (Hurst, 1905)
N	n	Small and large egg-mode (Hurst, 1913)
C	c	Brown and white egg-mode (Hurst, 1905–1913)

The first of each pair is dominant and the second recessive. In order to analyze the complex and continuous data of egg-production a system of uniform gradings was formulated, which ultimately led to the identification of the above genetic factors.

Sexual maturity was measured by age at first egg and graded in months of thirty days.

Early grades (E) were 4 to 8 and late grades (e) 9 to 13, so that each hen had a somatic grading E4 to e13, while each hen and cock had a genetic formula EE, Ee, or ee.

Rate of production was measured by percentage of eggs laid to number of days in lay, for each of the winter, spring, and autumn periods. These percentages were graded in tens.

Winter period was from first egg to last day of February, spring period from March 1 to June 30 and autumn period from July 1 to last egg of year.

Fast winter grades (W) and fast spring grades (S) were 8 to 3 and slow winter grades (w) and slow spring grades (s) were 2 and 1.

Slow autumn grades (M) were 0 to 2 and fast autumn grades (m) were 3 to 6.

Broodiness was measured by number of broody periods. Broody grades (H) were 6 to 1 and non-broody grade 0.

Egg-size was measured by weight of egg in ten equal grades of $\frac{1}{8}$ ounce ranging from $1\frac{1}{2}$ to $2\frac{1}{2}$ ounces. Small-egg grades were 1 to 4 and large-egg grades 5 to 9. The mode-grade of the first year's eggs was taken to represent the egg-size of each hen.

Egg-color was measured by grading in 6 color shades of equal difference of intensity from dark-brown to chalky white, viz.: Dark brown (5), brown (4), light brown (3), cream (2), ivory (1), and white (0). Brown grades 5 to 3 and white grades 2 to 0. The mode of the first year's egg was taken to represent the egg-color of each hen.

Four breeds were used in the experiments, namely, White Leghorn, White Wyandotte, Light Sussex and Pit Game, including three distinct utility strains of Leghorns and Wyandottes.

In the course of the experiments more than 50,000 eggs were recorded, and each egg was weighed and graded for size and color.

Four hundred and thirty pullets of four generations were reared from mated pairs, each pullet was tested for egg-production for one year after first egg where possible.

The unequal influences of the external conditions were minimised by the adoption of certain uniform methods of housing, feeding and exercise which involved the keeping of each individual in a single house and run. The factorial constitutions of 42 sires and 135 dams for the seven genetic factors were determined as far as possible.

The genetic constitutions of the birds were ascertained by a combination of the following four tests: (1) Somatic (hens only), (2) parental, (3) progeny qualitative, (4) progeny quantitative. This combination method of analysis was necessary owing to the comparatively small families of pullets raised from the mated pairs and proved to be critical in its complex harmonies.

The following table gives a summary of the results of the experiments with White Leghorns and White Wyandottes on the basis of the scheme of the seven pairs of factors and the genetic analysis involved.

Reduced to terms of dominants and recessives the total numbers are 1195: 687R showing a net deficiency of 17.75 dominants and a corresponding excess of recessives in the total of 1882 observations, or less than 1 per cent.

The gross divergence in the results of the seven factors amount to 29.25 or less than 2 per cent.

Summary of results in White Wyandottes and White Leghorns

CHARACTERS	TOTALS	DOMINANT	OBSERVED	EXPECTED	RECESSIVE	OBSERVED	EXPECTED
Sexual maturity..	335	Early (E)	286	289.00	Late (e)	49	46.00
Winter rate.......	266	Fast (W)	231	231.75	Slow (w)	35	34.25
Spring rate.......	224	Fast (S)	216	217.25	Slow (s)	8	6.75
Autumn rate.....	194	Slow (M)	140	145.50	Fast (m)	54	48.50
Broodiness.......	201	Broody (H)	50	58.50	Non. B. (h)	151	142.50
Egg-size..........	331	Small (N)	135	128.75	Large (n)	196	202.25
Egg-color........	331	Brown (C)	137	142.00	White (c)	194	189.00
Totals.........	1882		1195	1212.75		687	669.25

Eighteen definite exceptions appeared of which 2 proved to be somatic and not genetic, 10 were slight exceptions probably of the same nature 3 were pathological, 2 were possibly incomplete dominants, while 1 was apparently a true mutation.

Pearl's discovery of two genetic factors for winter production in Plymouth Rocks (1912) confirmed by Goodale and MacMullen in Rhode Island Reds (1918 and 1919) is also confirmed in White Leghorns and White Wyandottes. But as neither Pearl's factors L_1 and L_2 nor Goodale's factors A and B are individually identified with sexual maturity (E) or with rate of production (W), and as Pearl's factor L_2 is sex linked, while the others are not, it seems impossible to identify factors E and W definitely either with Pearl's L_1 and L_2, or with Goodale's A and B. No sex linkage was found either in the White Leghorns or White Wyandottes used in the experiments. In this respect these two breeds agree with Goodale's Rhode Island Reds rather than with Pearl's Plymouth Rocks.

No winter zero birds appeared in the White Leghorns, though 9 appeared in the White Wyandottes, and the White Leghorns. All were late maturers (ee) and all the five zeros tested genetically carried the factor W, so that Pearl's interpretation that the zero winter producers in Plymouth Rocks are mostly due to the absence of both production factors is not borne out in Leghorns or Wyandottes. The Wyandotte zeros on the contrary resemble Goodale's zeros in Rhode Island Reds, their zero production being due entirely to their very late sexual maturity. It is possible, however, that this very late maturity may be due to a genetic sub-factor.

In all the factors except H (broodiness) dominance tends to be incomplete, and the heterozygotes are more or less intermediate. In many cases it is

possible to recognize the homozygous individuals by their extreme grades, though not always.

In each of the seven main genetic factors for egg-production there are distinct indications of the presence of one or more sub-factors, but the numbers are insufficient to determine these and their allelomorphs satisfactorily. It is possible that an intensive study of a single set of these sub-factors would throw some light on the nature of the "fractional factors" of Bateson (1914) and the so-called "multiple allelomorphs" of Sturtevant (1913) and others.

There appears to be a definite difference of rhythm between the fast (W) and fast (S) birds and particularly between the discontinuous slow (w) and the discontinuous slow (s) birds, and it is not improbable that the slow (s) birds are pathological.

The M factor is clearly of a different nature from the factors W and S, seeing that in the two latter fast rate is dominant, while in the former it is recessive. A striking somatic difference was observed between M and m birds apparently coinciding with their different rates of production. The M birds are deep autumn moulters and slow producers, while the m birds are partial autumn moulters and fast producers. The m mutation, which has incidently made the "300-egg hen" possible, is interesting genetically on account of its comparatively recent appearance.

Owing to the fact that a sensible proportion of broody hens do not show their broodiness until their second season of laying, it has not been possible to ascertain the true nature of the "non-broodies" in the experiments, as most of them were only observed during their first laying year. Consequently the results show a deficiency of broodies. The appearance of a few broody exceptions in the non-broody Leghorns gives support to Punnett's (1920) suggestion of the possible presence of an inhibitor to the broody factor in certain non-broody birds. The evidence for the HI scheme for broodiness is admittedly incomplete, and experiments on a considerable scale would be necessary to demonstrate it. At the same time it seems to bring into line most of the complicated and conflicting data of the genetics of broodiness that have been published.

Evolutionary significance. The genetic results indicate the gradual evolution of the increase of fecundity in the hen by a succession of definite and discontinuous steps or mutations. Three of these mutations are dominant, viz.: early maturity (E), fast winter rate (W) and fast spring rate (S), while two are recessive, viz: fast autumn rate (m) and probably non-broodiness (h). A single case of the solitary appearance of a recessive mutation was observed, in the experiments, which apparently

originated in a male Wyandotte by the loss or absence of the factor N (small-egg mode) in a single gametogenesis giving rise to a daughter and granddaughters with large-egg modes (n). If the original mutation (n) arose in the same way in the wild species, at least two generations would elapse before it could appear owing to its recessive nature, and the lack of a recessive mate. In view of the recent contributions to the chromosome theory of the mechanism of heredity by Morgan (1919) and his colleagues, it is unfortunate that the above experiments do not provide many suitable matings for testing linkages satisfactorily, and investigations in this direction might lead to results of considerable genetic and economic importance.

Economic significance. It is obvious that these genetic results are of considerable economic importance, and the possibilities of their application to practical poultry breeding will be dealt with elsewhere.

Eugenic significance. From the problem of the fecundity in the domestic hen to the problem of fertility in man is admittedly a far cry. The cases are by no means parallel though they are in many respects analogous.

Pearl and Surface (1909) rightly distinguish fecundity from fertility, and use the term *fecundity* to "designate the innate potential reproductive capacity of the *individual organism*, as denoted by its ability to form and separate from the body mature germ-cells. Fecundity in the female will depend upon the production of ova, and in the male upon the production of spermatozoa. In mammals it will obviously be very difficult, if not impossible, to get reliable quantitative data regarding pure fecundity. On the other hand we would suggest that the term "*fertility*" be used to designate the total actual reproductive capacity of *pairs of organisms*, male and female, as expressed by their ability when mated together to produce (i.e., to bring to birth) individual offspring. Fertility, according to this view, depends upon and includes fecundity, but also a great number of other factors in addition. Clearly it is fertility rather than fecundity which is measured in statistics of birth of mammals."

We have seen above that at least five pairs of genetic factors are concerned with fecundity in the domestic hen, and if we accept Pearl's view that fecundity is only a part of fertility, we may expect fertility in fowls to be of a still more complex nature genetically. But the genetic factors of fertility, are only a part of the general problem of fertility, for to these must be added the multitudinous somatic or environmental factors, many of which are yet unknown to science.

If the problem of the causes of fertility in poultry is clearly so complex, one can hardly expect the problem of the causes of fertility in man to be of a more simple nature.

It is evident that there can be no eugenic control of fertility in man until the causes of that fertility are known, and the first line of attack might well be directed to the identification of the genetic factors of human fertility and sterility.

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INHERITANCE OF MENTAL DISEASE

A. MEYERSON

Boston, Massachusetts

I. INSANITY IS NOT A UNIT AND AS A TERM HAS NO PLACE IN THE SCIENCE OF MENTAL DISEASES

Like many another word insanity exercises a baleful influence over our thought. Originating in the idea that all mental disease was of the same general nature, and having its roots partly in the superstition that the insane persons are possessed, and partly in the legal concept of insanity as a condition in relation to the ability to care for one's property and one's social obligations, it has caused a marked confusion in psychiatric thought and especially in relation to the transmission from generation to generation.

Mental diseases are as different from one another as diseases of the respiratory tract. We recognize that tuberculosis is biologically an entirely different entity from the pneumonia caused by the pneumococcus, and that both differ from asthma, and that syphilis of the lung is in no wise related biologically except as to place of incidence with the previously mentioned diseases. Similarly with mental diseases there are types that are related to injury or disease of the brain, and the injured or diseased conditions vary biologically to a marked degree. Thus one of the commonest diseases is general paresis, which is caused by the Spirochaeta pallida or the organism of syphilis. This has no conceivable biological relationship to the mental disease caused by tumor growth. In fact, a tumor of the brain is biologically more related to cancer of the breast than it is to the rest of the subject matter of psychiatry. Trauma or injury to the brain causes mental disease but it is absurd to link this up with general paresis or tumor. Further, one finds mental disease in relation to meningitis and tuberculosis, and these conditions are related not so much to the other mental diseases but to the general problems of infection and its spread, and tuberculosis. In fact, psychiatry is a sort of nodal point into which a great many roads lead.

There are mental diseases caused by direct toxic influences. For example, alcohol caused somewhere from 15 to 20 per cent of all cases of "insanity." Morphine has its own type of psychosis, as have cocaine and heroin. Further, there are different mental diseases associated with toxemias of

pregnancy and with toxemias occurring in the course of other infectious diseases such as influenza, pneumonia, typhoid, etc. Then there are mental states of an abnormal kind and which become in many cases committable to insane hospitals, which directly follow great exhaustion. All of the above named groups of diseases are classed as toxic exhaustive psychosis. The heredity of these groups is nil or almost nil, as the figures from the Taunton State Hospital show.

There is a group of mental diseases of unknown origin, probably not related to any definite pathology of the brain at all, more likely related to disease of the endocrinal glands, and concerning which there is a remarkable diversity of opinion as to cause. For example, one group of observers think they have their origin in psychological traumata and trace them back to complexes of one type or another; others believe they arise in personality trends which become accentuated as time goes on into true mental disease; still others link them up with a disturbance of the endocrines, and another group tries to bring back their pathology to actual disease of the brain. In fact, no one knows their pathology, and this group is the only group of importance insofar as heredity of mental disease is concerned. This group comprises dementia praecox, manic depressive insanity and the involution psychosis, including certain of the diseases found in old age. As a matter of fact, even these diseases are not, biologically speaking, entities. There is at the present time great dissatisfaction in psychiatry with the scheme of classification by which they are designated as above. Take for example dementia praecox, one of the most common of mental diseases and isolated as an entity by the German psychiatrist Kraepelin. Ten years ago it was hailed as a triumph; today there are few who believe that this concept is anything more than a grab-bag into which many diseases are stowed.

II. CERTAIN OF THE STATISTICAL PHENOMENA RELATING TO MENTAL DISEASE

The neuropathic heredity of the insane and non-insane

This question has not been personally studied. The conclusions here stated are taken from the only two important studies on the subject, those of Koller and Diem. A few of their data are to my mind clear-cut enough to be important.

1. There is very much general neuropathic heredity in the direct and collateral relatives of both the insane and sane.

2. There is far more insanity in the families of the insane, and this is especially true of the parents and grandparents of the insane.

3. Insane uncles and aunts occur about as frequently in the families of the sane as in those of the insane; therefore, collateral insanity is of relatively little importance *unless associated with parental insanity.*

4. The sane seem to have as much, or even more, of nervous disease, senile dementia, and apoplexy in their ancestry. This would throw out of court as useless the questions as to nervous disease, apoplexy, etc., in insane hospital histories. It would entirely vitiate the value of such works as Davenport, in which apoplexy is considered a neuropathic taint when, as a matter of fact, the question is entirely arterio-cardio-renal.

The work of Koller and Diem is vitiated to a certain extent by the fact that both have taken insanity as a sort of unit and have regarded normality as something fixed. Nevertheless, their facts are of importance and similar studies need be done more scientifically and on a larger scale.

The marriage rate of the insane

In the four groups studied personally, including males and females—alcoholic insanities, general paresis, dementia praecox, and senile dementia—we find, first, that the males in the alcoholic paretic and dementia-praecox groups marry less than do the females. In the seniles, although the percentage of married men is greater, the totals of those who have entered conjugal relations at one time or another are about equal. Looking somewhat closer, it is found that in paresis there is only a slight difference in favor of the female, while in dementia praecox this difference is much further increased; thus, if these groups may be held to constitute a menace by virtue of their ability to transmit the psychotic taint to another generation, the female of the species, to use a well known phrase, is more dangerous than the male.

The seniles and the general paretics marry but slightly less than do the same age groups in the total population; the alcoholics show a decided falling off as compared with the total population; while the male dementia praecox has an exceedingly low marriage rate. That is, whatever is back of dementia praceox, it operates against self-perpetuation. Something of the same internal mechanism is seen in the case of alcoholism. This mechanism operates very little, if at all, in the case of paresis and the senile psychoses. One might conclude that if there is an inborn defect in these diseases it is by far greatest in dementia praecox, is next in alcoholic insanity, and least of all in syphilis and the senile psychoses.

We are shown that marriage acts as a barrier to the propagation of the abnormal insofar as this is connected with endogenous factors. It is not a barrier against certain of the exogenous race poisons, such as, for example,

syphilis, at least in that form which leads to paresis. We need to strengthen the barrier against the endogenous diseases, as for example, dementia praecox, but not nearly so much as we need to strengthen it against the exogenous, as, for example, syphilis.

General statistics

For the purpose of comparison, figures obtained by Mott in his studies have been included in the following summary.

1. More females than males are concerned in family psychoses. The studies at the Taunton State Hospital show 808 females and 739 males.
2. The mother-daughter group is much more common than the father-daughter group—80 to 59, as shown by the Taunton figures; 137 to 103, as shown by Mott's figures.
3. The mother-son groups are about equal.
4. Mother-son and father-son are about even—56 to 59, in accordance with Taunton figures; 96 to 88, as shown by Mott's figures.
5. Sisters alone decidedly outnumber brothers alone—80 to 57 according to Taunton figures; 211 to 140, according to Mott's figures.

If insane women transmit their mental peculiarities to their female children more than they do to their male, then the greater marriage rate amongst insane women may decidedly play a part in determining the preponderance of insane women. Furthermore, men migrate more than women, and so in any given hospital district the female descendants of insane ancestors would be more apt to appear in the asylum than the male descendants even if given equal rate of incidence. That is to say, a larger part of these men would end in jails or in hospitals in districts remote from their former homes, etc.

Anticipation or antedating

This term is used (Darwin) to describe the earlier appearance of mental disease in the younger as compared with the older generation. This phenomenon has been given great prominence by Mott and his co-workers. He regards it as an effort of nature to get rid of the disease by crystallizing it in a few descendants and making them more easily vulnerable or unfitted to propagate by being brought early to hospitals. There are thus in Mott's definition of anticipation, first, a crystallization of the insane elements, leaving other descendants free from disease, and second, earlier onset of the psychosis in the affected members.

All of the figures, and especially in the second-generation cases, seem to point clearly to the validity of the phenomenon of antedating or anticipa-

tion. A closer examination, however, shows one great fallacy underlying the statistics and that is as usual, the method of collection. In a majority of cases the period of time during which the cases have collected is not clear (for example, in Mott's statistics, where no mention is made of the period during which his figures have been collected), but it is generally within thirty years. As the average ancestor is at least that much older than his average descendant, it would be practically impossible for the descendant to be older than the ancestor at time of commitment, and the age difference between ancestory and descendant would generally be from thirty-three years to zero, in favor of the ancestory, and in certain cases where the descendant enters the hospital before the ancestor it would be thirty years or more. This means that in the cases of some of the investigators it has been possible for the younger descendants to enter the hospital, but time enough has not elapsed for the older descendant to arrive. As the Taunton figures have been collected since 1854, this objection does not obtain with such force. Nevertheless, the rate of commitment has increased within the last generation so that even in my cases the bulk of families has arrived within the last thirty years and thus the factor stated above still plays its part in falsifying the manifest results.

It is probable, therefore, when all is said and done, that in a very large proportion of cases the descendants of the insane who themselves become insane do so at an earlier age than their ancestors. Moreover, as is well known, these descendants have a much lessened chance for marriage and so this factor of anticipation seems to be, as Mott believes, a potent factor for race regeneration through elimination. One need not, of course, subscribe to any such anthropomorphic absurdity as that nature has any intentions in the matter. It is perhaps better to speak of this phenomenon as the downward trend of psychiatric families, just as the same descendants represent their upward trend.

The transmission of mental diseases is practically nil insofar as the organic disease of the brain goes. It may be stated on the basis of personal research that there are very few families in which mental disease occurs generation after generation in anything like the way other hereditary characters are transmitted. At the Taunton Hospital there are records of one four-generation family; there were eighteen families in which three generations were represented on the records. In the majority of these cases the relationship of the mental disease of the grandparent to the mental disease of the grandchild was in great doubt, and in fact, in the majority of cases there was a much clearer relationship to some factor entering with a new line of ancestors. In other words, it is rare that one can see a direct relationship

between a mental disease in a grandparent and one in a grandchild. The mental diseases which occur in two generations are very common. On the whole the following may be stated. Other mental diseases besides dementia praecox, manic depressive insanity, and the involution psychoses rarely, if ever, can be shown to have a direct hereditary value. This is true of the alcoholic psychoses. That is to say, the fact that an ancestor has a mental disease due to alcoholism does not seem to predispose his descendant to mental disease of other type. A fairly uniform relationship can be shown between the mental disease of the ancestor, the mental disease in the parent, and the mental disease in the child somewhat along these lines (if the child is subject to mental disease for it needs here be emphasized that the great majority of the descendants of this class of the insane do not themselves become insane):

1. Given a paranoid type of psychosis, including in this term true paranoia, paranoid dementia praecox, and unclassified paranoid states, what types of mental disease may we expect in the descendants? The answer is definitely that we may expect either paranoid disease or ordinary dementia praecox in the insane descendants, and this statement is corroborated by Jolly, Luther, Krueger, Rosanoff, and Albrecht. Practically no manic-depressive descendants appear.

2. Given well defined dementia praecox in an ancestor, what type of mental disease may we expect in the descendant? Dementia praecox follows in the large majority of cases. Feeblemindedness of a type which is perhaps very early dementia praecox is relatively common. Epilepsy is noted. Manic-depressive insanity occurs very rarely if at all.

3. Given a well defined manic-depressive insanity in an ancestor, what type of mental disease may we expect in the descendants? There appear to be two main trends, one toward manic-depressive insanity and the other toward dementia praecox. Difficulties in diagnosis play a large part in solving this particular question, but it is certain that short attacks of mental disease bearing the earmarks of manic-depressive in an ancestor are followed in insane descendants by a definite dementing psychosis corresponding to what this uncertain generation calls dementia praecox.

4. Given an ancestor with involution psychosis, what type of mental disease may we expect in the insane descendant? It seems to be universal experience that dementia praecox follows involution psychosis and that apparently no matter what the type of the involutional insanity.

5. Given an ancestor with senile psychosis, what type of mental disease may we expect in the insane descendant? The Taunton figures, as well as those of Vorster, Albrecht, Jolly, Luther and Krueger, all find that what is

termed "senile dementia" is of such heterogeneous nature that what might be expected, occurs; that is, dementia praecox, manic-depressive, paranoid psychoses, imbecility and epilepsy, all are found in the insane descendants.

If, then, we survey the facts which have here been presented together with the trends observed in the literature, we find that the paranoid and catatonic diseases trend finally to dementia praecox; that manic is succeeded by manic and in a varying proportion of cases by dementia praecox; that the senile and involutional psychoses, if paranoid, or more properly involution and senile, trend towards paranoid diseases and dementia praecox. Manic states of the senium follow the rule of manic states elsewhere. Neither for organic brain disease nor alcoholic psychoses can anything very definite be said, except that in the cases studied, wherever adequate history has been obtained, the psychosis in the descendant of the alcoholic or of the patient with organic brain disease can be related to some other more definite psychopathic feature than either alcoholism or organic brain disease. It will thus be seen that all roads seem to lead to dementia praecox and from thence to imbecility.

With regard to the horizontal transmission of insanity, it may be thus restated: Given an insane person, what psychosis may we expect in his insane brothers or sisters?

1. The psychoses of brothers and sisters trend on the whole to be of similar type.

2. If one brother or sister has dementia praecox, the chances for dementia praecox in any other insane brother or sister are very great. Feeblemindedness, or what is called feeblemindedness, occurs frequently. This, as has been before stated, may merely be congenital dementia praecox with dementia as the leading feature.

3. Manic-depressive insanity and dementia praecox are said to occur together in the same family group of brothers and sisters. Such cases are usually atypical, and really clear-cut cases with such association are rare.

III. GENERAL REMARKS

This paper has attempted to emphasize in a very brief manner the fact that mental diseases are not unitary and that each type of mental disease must be studied by itself in order to discover its hereditary relationships. Most of the mental diseases have no hereditary relationships; a few as stated above do. Any individual whose candidacy for matrimony is being considered need not hesitate to marry if his ancestors have died in insane hospitals of the organic brain diseases, of alcoholic insanity, and of those groups which are non-hereditary, but the situation is entirely different when those diseases which have been discussed above are concerned.

We are very far from establishing the fact that we are dealing with biological entities concerning which we may make any kind of general conclusions in relation to heredity. The insane have normal descendants; normal folk have insane descendants in a perfectly bewildering and inexplicable fashion. When all the facts are gathered in an impartial manner this is the one phenomenon that stands out. It is more likely in my opinion that we are dealing with a disease of the germ-plasm and injury inflicted upon it, which is thereupon transmitted for a long or short time through one or more generations according to the severity of the injury. There is plenty of evidence at present collected to show that germ-plasms can be so injured and that the disease may thereupon appear without further injury, be inflicted on successive generations, and in fact grow worse as time goes on. The work of Stockard and his associates, the work done in transmitting diseases of the lens, and certain evidences adduced by Forel and his associates concerning what they call blastophoric influence is of high significance. As eugenists we must not blind ourselves to the fact that stocks may become sick in the same sense that individuals do; that this sickness may pass down for several generations and then the stock recover exactly as does an individual from an infection, though of course the stock may die just as the individual does. The most fertile work that can be done at present in the study of the inheritance of mental disease is to look for the agents that injure germ-plasms rather than try to link up the transmission of mental disease with the phenomena of Mendelism or other great biological laws. In other words the problem of the transmission of mental disease is a clinical medical problem to be studied by laboratory methods as in the rest of experimental medicine.

INHERTIANCE OF MENTAL DISORDERS

AARON J. ROSANOFF

Kings Park State Hospital, Kings Park, Long Island, New York

The object of this communication is to present a summary of the more important known facts concerning the inheritance of mental disorders and to attempt a synthetic treatment of them.

Mental disorders consist of a series of more or less sharply defined clinical entities on the causation of which variable relative parts are played respectively, by inborn and environmental factors. Numerically the most important group consists of those disorders which have, by a sort of common consent, been designated *constitutional,* the implication being that the inborn factors play an essential part in their causation. It is with this group that my paper deals.

The principal clinical entities included are: mental deficiency, epilepsy, dementia praecox, paranoia, manic-depressive psychoses, psychoneuroses, and psychopathic personalities. A more detailed classification of them is given in the following chart.

Mental deficiency	Idiocy Imbecility Moronism Borderline intelligence
Epilepsy	Epileptic personality Psychotic episodes Epileptic deterioration
Paranoia	Various monomanias
Dementia praecox	Simple form Hebephrenic form Catatonic form Paranoid form
Manic-depressive psychoses	Depressed form Manic form Mixed and alternating forms Involutional forms

Psychoneuroses	Hysteria Neurasthenia Psychasthenia
Psychopathic personalities	Inadequate personality Paranoid personality Emotional instability Criminalism Pathological lying Sexual psychopathics Nomadism

Institutional experience shows that the constitutional mental disorders run in families, and special statistical studies point to heredity as being the origin of psychopathic constitutions (1, 2, 3). The latter fact is today no longer in question; but there is considerable difference of opinion as to the relative amounts of causation attributable to heredity and to other factors.

The obvious reason for this difference of opinion lies in our inability to measure exactly the factors involved. Rough measurements are, however, possible, and accumulated evidence seems to be to the effect that the relative importance of the factor of heredity varies in individual cases, first, with the clinical subdivision, and, second, within each subdivision, with age of onset, amount of demonstrable external cause, intensity of manifestations, their intractableness or persistence in spite of treatment, etc.

Thus, mental deficiency and, to a lesser extent, epilepsy are subdivisions in which heredity alone in most cases determines the manifestations. On the other hand, psychoneuroses, especially hysteria, most often develop in reaction to special external situations, being, under usual conditions, latent. Other subdivisions hold, in this respect, intermediate positions.

Within the same subdivision, say that of dementia praecox, are found, on the one hand, cases which present abnormal psychic traits all through childhood, onset of grave psychotic symptoms at puberty or before in the absence of pathogenic environmental influences, and rapid passage into chronicity and deterioration in spite of all efforts of treatment; and on the other hand, cases in men of apparently normal psychic make-up, who, perhaps at middle age, following financial and marital troubles, take to heavy drinking and develop an acute hallucinosis or some other schizophrenic episode, which subsides under no other treatment than a few days' rest in a hospital.

A highly significant fact is that of frequently observed atavistic heredity: after one or more generations in direct line of descent have been skipped, an ancestral mental disorder reappears, sometimes affecting two or more individuals in a sibship. From a Mendelian standpoint this is, of course,

suggestive of recessiveness in relation to normal mental constitution. This seems to be true of all constitutional mental disorders, regardless of variety, with the possible exception of the manic form of manic-depressive psychoses (4, 5, 6, 7).

Another significant fact is that of dissimilar heredity. All psychopathic members of a given family do not necessarily suffer from the same clinical form of mental disorder. More often than not they differ from one another either qualitatively, i.e., in respect of clinical variety, or quantitatively, i.e., in respect of severity of the disorder (8, 9, 10, 11, 12).

The manner of distribution of the different clinical varieties of mental disorders in a family is apparently not a random one. Many studies have resulted in the observation that, although manic-depressive ancestors not infrequently have dementia praecox descendants, the reverse is very rare (13, 14, 15, 16).

Based upon this and other similar observations a theory has been suggested, according to which the various psychopathic conditions possess different degrees of recessiveness and may be ranged in a scale of dominance in the following order: normal condition, manic-depressive psychoses, dementia praecox, epilepsy (7, 11).

The fact of some sort of relationship of the clinically distinguished entities to one another is suggested not only by family studies, but also by the existence of transitional and borderline cases presenting mixed manifestations: dementia praecox with epileptiform convulsions; manic-depressive psychoses with an admixture of catatonic, delusional, hallucinatory, or other schizophrenic symptoms; psychoneuroses with occasional elated or depressed spells, etc. (11, 17, 18, 19, 20).

The exact definition and measurement of the several clinical entities are rendered difficult by the fact of the great variations in their manifestations in different cases and in the same case at different times. These variations are spoken of among medical men as equivalents. Progress in psychiatry in the past two or three decades has been marked by a simplification of classification through a far reaching extension of the conception of clinical equivalents; and it would seem that a further extension of this conception is indicated by new accumulations of material (7).

What bearing has our accumulated knowledge of the part played by heredity in the production of mental disorders on applied eugenics? Would there be justification in advocating restriction of propagation in all cases in which signs of constitutional mental disorder can be definitely established?

In this connection it is sometimes forgotten that the aim of eugenics is not only to prevent the propagation of socially undesirable traits, but also

to conserve and stimulate the propagation of socially desirable ones. The great majority of individuals, insane as well as sane, present combinations of desirable and undesirable traits in endless variety. A general judgment seems hardly possible; each case must receive special consideration. The presence of a mental disorder in gravest degree is not incompatible with intellectual activity of the highest order and value to society, as is witnessed by the cases of Jean Jacques Rousseau, Gustave Flaubert, William Cowper, Auguste Comte, Julius Robert Mayer, Foodor Dostoyovski, and many others (21).

Moreover, judgment as to desirability or undesirability of a given trait is apt to vary in different countries, or parts of countries, or, in the same country, at different times, depending on type of civilization and prevailing social ideals and standards. It would seem to be a part of a healthy conservation to refrain from the employment of any eugenic measure which is irrevocable—such as sterilization—at least for the present. Against segregation, on the other hand, there is no such objection. It meets, indeed, not only the requirements of eugenics, but also other social requirements, and should be even more freely practiced than it is.

Segregation is a measure which requires no forcing. Existing institutions are greatly overcrowded and many of them have long waiting lists. It has been estimated that even in a state like New York, which stands among the highest in respect of providing facilities for segregation, such facilities would have to be doubled before the existing demands could be met (22).

On the scientific side the most urgent need seems to be two-fold, (1) to define more clearly the various qualitatively distinguishable psychopathic traits, including a fuller knowledge of clinical equivalents, (2) to devise for temperamental traits methods of more precise measurement, as has already been done for intellectual traits.

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INDIVIDUAL AND RACIAL INHERITANCE OF MUSICAL TRAITS

CARL E. SEASHORE

Division of Anthropology and Psychology, National Research Council, Washington, D. C.

Instead of reporting a particular experiment, I embrace the opportunity to lay before this Congress the general result of a number of series of experiments. This result or issue may be summed up in the statement that musical talent is resolvable into a number of inborn natural capacities which may be isolated and measured or rated adequately for statistical or experimental purposes.

Through a sustained teamwork of collaborators for many years, we have gradually designed and made available the necessary measuring instruments, standardized procedure, and established norms and other matters of technique for many of these factors.

I wish here especially to call attention to their availability in the study of racial differences as well as the study of individual differences in the experimental investigation of the inheritance of musical talent. The relation of these to eugenics is self-evident.

The approach to the problem of inheritance of musical talent, from the point of view of eugenics, divides itself naturally into five stages or tasks: (1) the analysis of what constitutes musical talent and the isolation of measurable factors; (2) the development and standardization of methods of measurement and rating of each of these talents under control; (3) the actual field work of measuring sufficiently large numbers of generations in selected family groups; (4) the interpretation of such results in terms of biological principles of heritable factors; and (5) interpretation and dissemination of established information for eugenic guidance.

The first and second of these stages I have treated at length in an introductory way in a recent volume entitled "The Psychology of Musical Talent."[1] In attempting such isolation and control of the factors for the purpose of measurement and rating we are confronted with numerous difficulties, complexities, and dangers, of which frank recognition is the first step in scientific procedure. Some of these I have outlined in a recent

[1] Silver, Burdett and Company, 1919.

article in *The Musical Quarterly*[2] on "The Inheritance of Musical Talent," pointing out that musical talent is not one but a group of hierarchies of talent, each highly organized; that measurement and appraisal of musical talent must take cognizance of the possession of *capacity* rather than of evidence of *achievement;* that, although the musical geniuses and musical defectives present interesting types for investigation, the musical mind is the normal mind; that we must distinguish between the talented person and the genius in music; that the versatility and the plasticity of the human organism offer most extraordinary resources for adjustment under handicap; that scientific procedure encounters peculiar difficulty in dealing with the artistic attitude of the musician; that we can not appeal to any generally recognized biological theory of mental inheritance; that we must discard the literature on musical inheritance now extant, because it is not based on scientific conceptions of the musical mind; and that we must, with patience and forethought employ the methods of experimental psychology for the analysis of musical talent and for the measurement of talents for statistical purposes, in spite of the slowness of the procedure.

On the third stage we have driven an entering wedge in the survey of six prominent musical families on which Dr. Stanton is scheduled to report at this session.

The eugenist might rightly expect me to recite established facts on the inheritance of musical talent and present arguments showing that they should be applied. But the time is not yet ripe for either. The object of this paper is merely to present a point of view, showing that such facts can be gathered; and this is done in the anticipation that, once established, the desirability of their application will be taken for granted by those who are interested in this phase of eugenics.

In the few minutes available for this report, I shall limit myself to some remarks on the selection of measurable factors and the organization of experiments covering a sufficient number of generations and families.

We must at once abandon the idea that a person is either musical or not musical, that the gift of music is one gift or one talent. In view of this I have drawn up in tabular form what, at our present stage of experimental analysis, would seem to be isolable factors of musical talent that may be inherited.

[2] The Musical Quarterly, Schirmer Company, October, 1920.

Isolable Factors of Musical Talent that may be Inherited

I. SENSORY CAPACITIES

A. Pitch

1. The sense of pitch
2. The sense of timbre
3. The sense of consonance

B. Time

4. The sense of time
5. The sense of rhythm

C. Intensity

6. The sense of intensity
7. Acuity throughout the pitch range

II. MOTOR CAPACITIES

A. Pitch

8. Instrumental control of pitch
9. Singing of (1) key, and (2) interval
10. Rating of (1) timbre and (2) range of voice

B. Time

11. Free timed action
12. Regulated action
13. Rhythmic action

C. Intensity

14. Instrumental control of intensity
15. Volume of voice

III. REPRESENTATIVE CAPACITIES

A. Imagery

16. Auditory
17. Motor
18. Visual

B. Memory

19. Auditory memory span
20. Visual-motor association
21. Auditory-motor association
22. Speed and accuracy of learning

C. Imagination

23. Imagination type
24. Creative imagination

IV. GENERAL CAPACITIES

25. Intelligence quotient
26. Emotional type

Fundamentally there are three groups of talent corresponding to the three elements, pitch, time, and intensity in music; and these are represented at four levels, namely, the sensory, the motor, the representative, and the higher cognitive and the emotional.

Sensory capacity for pitch is represented typically in measurements of the sense of pitch, the sense of timbre, and the sense of consonance, dealing respectively with a simple tone, a rich tone, and combinations of tone as in harmony. These are probably closely related and may be regarded as one factor dependent upon the character of the tone analyzing mechanism in the organ of Corti. Measurements of the sense of time and the temporal aspect of the measurement of the sense of rhythm probably represent another entirely independent factor; but we must remember that rhythm is a complex of several factors. The sense of intensity measures the natural capacity for hearing distinctions in the loudness of sound. This seems to be quite unrelated to the acuity of hearing, as the sense of intensity may remain unimpaired for audible sounds where the acuity is markedly defective.

The motor capacity for the control of pitch depends upon two factors, namely, general motor control and capacity for hearing pitch. This talent differs in control of pitch in instruments and in voice, each of which may be measured separately; and both for instrumental and vocal control of pitch there may be distinct and unrelated factors, such as the gift of wide range of pitch, or a beautiful tone quality as represented by timbre in the natural voice. On the motor side the free timed action and regulated action as they appear in the temporal aspect of rhythmic action probably represent a single factor. In the motor capacity for control of intensity we may recognize the natural capacity for volume of voice and a capacity for precision in the control of intensity of sound either by voice or instrument in musical expression.

Turning to the capacities for mental representation of music, we recognize distinct variables in auditory, motor, and visual imagery; and, in musical memory, we recognize as distinct factors, the auditory memory span, visual-motor association as in sight reading, and auditory-motor association as in playing by ear. These three taken together are the chief determinants of speed and accuracy in the acquisition of skill in music. It seems probable that fairly distinct types of imagination may be identified;

and capacity for creative work is a comparatively rare gift which may be recognized in different types.

Two general capacities have distinct value in the rating or valuation of musical talent, namely, the intelligence quotient and the emotional type.

In judging the merits of this or any similar analysis of measurable or ratable capacities, we must bear in mind that the analysis is made for the purpose of controlling conditions in experiment and does not rest upon any assumption to the effect that these factors operate singly or in isolation in the exercise of music. The isolation of factors of this kind is, however, absolutely essential in order that we may deal with specific, repeatable, measurable and describable situations. To illustrate, the sense of rhythm, auditory imagery, and intelligence are isolable for the purpose of measurement, although in musical appreciation and expression they are integrated into one factor.

However inadequate this preliminary analysis, it paves the way for the asking of specific questions, such as, is the sense of pitch, is the sense of time, is auditory imagery, is musical imagination, is a voice of large volume, is a voice possessing a given tone quality, heritable?

This list of factors must be considered as tentative and lacking in detail. It is merely intended to point the way. Refinement and relationship must be based upon further experiment.

As to the reference of these elements of musical talent to biological factors, determiners, or carriers in the mechanism, we are only in a position to assert that it may be feasible.

There should be no confusion from the fact that some of these factors are designated from the mental and others from the physical point of view; from the psychological point of view, all are psycho-physical; and, in observation and measurement, we regard a factor for one purpose from the mental and for another from the physical point of view.

Likewise, we must recognize that a given capacity which is an essential factor in musical talent may be of general or specific significance in countless other mental activities. Indeed, all the capacities here listed have a wider scope than for music. Thus general intelligence is not an exclusive musical capacity, yet that factor determines the degree of intelligence that may be exhibited in the musical talent of an individual.

Let us turn then for a moment to the problem of the organization of this experiment. Granting that we know what we wish to measure and how to measure it, the staging of an experiment to determine the laws of the inheritance of musical talent in human beings is not different from the staging of an experiment on the inheritance of color in peas, the milk-

producing quality in cows, or speed in race horses, except that there are more factors to take into account and the experiment will take longer.

There are several ways in which the experiment may be organized. With plants and animals you select a colony and breed successive generations under observation. With human beings you could select a sufficient number from volunteers in which the factor under control is mated in a known way and examine them and their children's children and their mates in successive generations. We might, for example, select one hundred newly married couples from volunteers, in which we have as large a variety of matings as possible with reference to the presence or absence of musical talent, with the understanding that an endowment provides for the measurement of their children and their children's mates in successive generations. In this way we should follow the very principles that are followed in plant and animal colonies for the study of inheritance. There is nothing offensive or forbidding in applying this method to musical inheritance in human beings. Indeed, the experiment should be most delightful and should present a great variety of points of interest for science, art and society.

Such an experiment would require forethought and stability of organization; but it would be relatively inexpensive, since the scope might be limited to the number of persons that could be measured by one expert permanently employed. Nor would the results be discouragingly remote, because they would have cumulative significance from the time of the measurement of the first generation, and the remoteness might be shortened by selecting the parents at the time the children are of measurable age instead of the time of marriage, providing the selection is not made at all on basis of the showing of the child.

In plant and animal experimentation it is customary to take only one factor under control and run that intensively, but, in view of the complexity of the situation in musical talent, the expense involved, and the necessity for carrying the experiment through several generations of human beings it would be advantageous to select a large number of measurements, each representing more or less unrelated factors, and make these records on the members of each generation. Such a list might be selected from the list of twenty-six items mentioned in our inventory, or at least on the principle of that inventory.

A more direct approach is to do as Dr. Stanton has done,—select a musical individual who is distinguished for his achievement and measure his mate, ancestors and progeny, as far as available. This has the advantage of grouping about a conspicuously talented person and obtaining significant results from a few cases.

Another method would be to take selected families who have children of measurable age and measure the parents and children at the same time, taking large numbers of cases so as to get statistics from matings that represent great variety of talented and untalented persons.

It would be bold speculation to try to guess the countless and far reaching scientific facts on the inheritance of these mental traits that might be discovered by such methods of procedure. The experiment is particularly worth while because musical talent lends itself well to measurement and the possession of this gift is of great human interest.

It is a matter of common observation that we make fairly definite prediction of the chance of reproducing a given quality, such as shortness of stature, and talk wisely about the chances of this when two short people mate, when one short and one tall mate, when two short people all of whose ancestors on both sides were short, or one whose ancestors on one side were short and on the other side tall, etc., in various combinations in receding generations. And from the experimental work that has been done on plants and animals, we are finding the explanation of these common sense predictions and establish greater confidence in the predictions. The same is, to some extent, true about the inheritance of musical factors. Suppose that we substitute for stature, the sense of pitch, the sense of rhythm, musical memory, musical intellect, creative imagination in music, register of voice, range of voice, volume of voice, etc., and regard these as independent factors. Our common sense observation gives us some feeling of assurance in the power to predict these; and it is the aim of this paper to maintain that a scientific knowledge of heredity will increase our power of prediction of musical talent in the same sense that it has advanced the prediction of stature.

Is such knowledge worth while? Is the rose less beautiful to the botanist than to the ignoramus? Is the choice of a mate less of a love affair because one has the power to understand and know some of the laws of life of the thing he adores? When the first baby came into my home there was a "ladies' aid" meeting across the street, and it is reported that one of the good ladies exclaimed, "That poor Seashore child!" All ears were open for alarm. "What is the matter?" The reply came, "His father is a psychologist!" Yet I have a feeling that my love for my children is none the less genuine and intense for the fact that I have some scientific knowledge of child life. Should not my love for my children as compared with the love of one who knows nothing about child nature be as the botanist's or horticulturist's admiration for a flower is as compared with the ignorant peasant's admiration of the same flower?

In other words, suppose a youth is endowed with a wonderful musical mind and imbued with a deep desire to have children endowed with the same precious gift. Would it be an advantage to have definite knowledge and insight in the predictions on the basis of family history, for each of the factors I have described, such as, the sense of pitch, musical imagination, and quality of voice and be able to say that the chances are 10 to 1, 1 to 1, 1 to 2, 1 to 5, 1 to 10, or 1 to 100 that this factor shall be reproduced? If youth enters into wedlock in possession of this knowledge, will that not tend to a deepening of love to the extent that it carries with it confidence of great promise? The opponents of eugenics fail to realize that scientific facts when well established become a part of common sense and a basis of intuitive reactions. My proposition is that if certain musical talents are heritable, as we believe them to be, it is quite within the power of future generations to enhance the quality and degree of a musical talent by conscious selection. The great significance for eugenics, however, lies not in the development of a system of artificial and formal eugenic guidance, but rather in the popular assimilation of well established facts in the common sense of the age and the naive projection of this common sense in natural reaction in courtship and mating.

AN EXPERIMENTAL INVESTIGATION OF MUSICAL INHERITANCE

HAZEL M. STANTON

State University of Iowa

This paper is a report of a recent investigation of the inheritance of musical talents made from the Eugenics Record Office of the Carnegie Institution of Washington. The purpose of initiating such an investigation was to establish technique for studying the inheritance of musical talents by means of quantitative measurements. Four of the Seashore measures of musical talent, viz.: The sense of pitch, the sense of intensity, the sense of time, and tonal memory, were given to members of families in which one member was known to be conspicuously talented in music. These measurements were developed and standardized from the Music Laboratory Studio of the State University of Iowa under the direction of Professor C. E. Seashore, head of the department of philosophy and psychology. During the past eighteen years extensive experimentation has revealed the apparent basic nature of these measurements and has shown them to be little affected by practice, age, musical training, sex and intelligence. By this I mean that when a reliable result is obtained from an individual, for example, a superior record in the sense of pitch, there will be little or no variation in this record on repetition of the measurement under similar conditions, children may do as well, better or poorer than adults, the same measure may be given to those with no musical training as to those with musical training. We are measuring basic capacities, capacities which a child possesses by right of birth and not what he acquires during training.

The measurements of intensity discrimination, time discrimination and tonal memory were given by means of phonographic records on which stimuli from the standard laboratory apparatus have been recorded by Professor Seashore. For the measurement of the sense of pitch in terms of pitch discrimination, the standard pitch discrimination forks with resonators were used in place of the phonographic record, first, because the forks are better adapted for very fine measurements, and second, in order to introduce variety in the procedure.

Pitch discrimination was measured by pitch intervals ranging from 30 d.v. to $\frac{1}{4}$ d.v. in a tonal region of 435 d.v. The observer discriminates

between two tones differing in pitch, the second tone presented being higher or lower than the first. For the purpose of intensive work the individual method of constant stimuli was used. The threshold values, computed from conversion tables, may be determined to tenths and hundredths of one vibration.

Intensity discrimination, time discrimination and tonal memory were studied by means of the serial stimuli method. Intensity discrimination is a measurement of the capacity for discriminating differences in intensity or loudness. This measurement contains five graduated steps, the first easily perceptible, the last difficult to perceive.

The measurement of time discrimination refers to an individual's capacity for discrimination between two time intervals, the second interval presented being longer or shorter than the first. The stimuli cover a range of steps from an easily perceptible difference of 0.20 of a second to a difference of 0.02 of a second. Such a measure of an individual's capacity for discriminating time intervals is not a measure of rhythmic perception but a measure of one of the basic constituents of rhythm. It gives one partial knowledge of the sensory aspects of rhythm, the receiving of an elementary impression of time.

The measurement of tonal memory is a measure of immediate memory for a span of tones. It consists of five steps gradually increasing in difficulty, each step containing a certain number of successively presented tones, followed by a second span of the same tones with the exception of one tone which is changed in pitch. The observer identifies the changed tone by indicating its number in the group. The spans increase gradually in presentation from a group of two tones to a group of six tones.

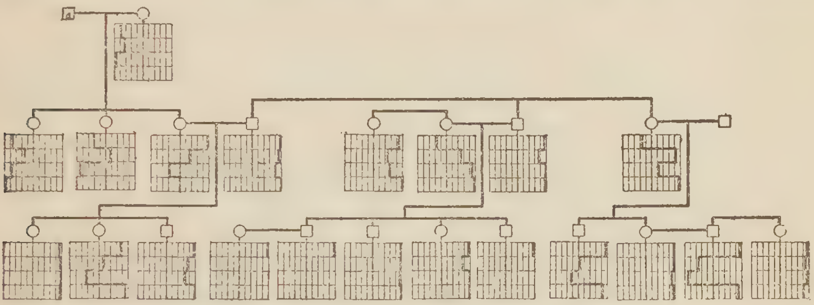
These four measurements were supplemented by a special interrogation dealing with individual case histories, individual musical experiences, including musical environment in the parental home and in the community, musical education and training, musical activity, musical appreciation, musical memory and imagination, family musical history, and a short association test.

In selecting the musicians from whom a family study could be developed we chose those who were available for an interview during the months reserved for their section of the country and who had families, the members of which were significant in number and available for appointments. In so far as possible a family study included all the members of the restricted family. Individual interviews averaged two hours in time. The four quantitative measurements were given to 85 individuals comprising six families. The qualitative information was obtained for 531 individuals.

The order of presenting the measurements and the supplementary information to an individual was, first, the measurement of pitch discrimination with the tuning forks; second, the free association test; third, the three measurements on the phonographic records, viz., the sense of intensity, the sense of time, and tonal memory; fourth, the systematized interrogation covering case histories and musical experiences.

Norms for each measurement have been established for three age groups, viz., fifth grade pupils, eighth grade pupils, and adults.

The results of the quantitative measurements are presented as follows: the final score of all the measurements is determined in terms of percentile ranks consisting of a standardized distribution of results ranging from 1 to 100. The individual ranks are presented in the form of individual talent charts as seen on the pedigree talent chart below. One family is charted



with the individual talent profiles for every member to whom the measurements were given. The percentile rank obtained in each measurement is presented in the horizontal sections. The sense of pitch rank is recorded in the upper section, the sense of intensity in the second section, the sense of time in the third section, and tonal memory in the lower section. All ranks extending to the right of the middle line of each chart are above average, those to the left are below average. Time does not permit discussion of these charts in their relation to musical experiences for each individual.

The results of the qualitative information have been analyzed and rated into three groups of A, indicating high rating; C, average; and E, low. By direct comparison of the results obtained in the measurements and the qualitative ratings of musical information, those possessing the highest 5 per cent talent profiles are also high in ratings of musical experiences; those possessing the lowest 5 per cent talent profiles lack musical interest, and have experienced no musical activity.

The results of the measurements when distributed according to the six types of matings, viz., superior x superior, superior x average, average x average, superior x poor, average x poor, and poor x poor, show the following distribution of offspring for each measurement in so far as examples of each type were obtained. In pitch discrimination both parents superior, of 16 offspring 15 were superior and 1 average; one parent superior and the other average, of 11 offspring all were superior.

In intensity discrimination, both parents superior, of 7 offspring 6 were superior and 1 poor; one parent superior and the other average, of 6 offspring 5 were superior and 1 average; one parent superior and the other poor, of 11 offspring 5 were superior, 4 average and 2 poor.

In time discrimination, both parents superior, of 5 offspring all were superior; one parent superior and the other average, of 6 offspring 3 were superior, 2 average and 1 poor; one parent superior and the other poor, of 8 offspring, 5 were average and 3 poor.

In tonal memory, both parents superior, of 5 offspring 4 were superior and 1 average; one parent superior and the other average, of 17 offspring 14 were superior, 2 average and 1 poor.

In partial answer to the question regarding the tendency of musical or non-musical parents, of musical or non-musical stock, to have musical or non-musical children, the following statements based upon 22 matings have been deduced from the qualitative data. Of 11 children of musical stock all were musical except 1 whose normal growth was stunted. Of 25 children of non-musical stock all were non-musical. Of 17 children from parents, one of whom was musical and the other non-musical, 6 children were very musical and 11 were non-musical. Representative matings of the other types were insignificant in number.

In presenting this study to you I call your attention to a few of the outstanding difficulties and limitations immediately encountered; first, the limited number of individuals upon whom preliminary conclusions are based; second, the accumulation of results into the average and above average groups, leaving a paucity of results in the poor group; third, the extreme variation in age ranging from eight years to eighty years, which adds new problems to the experimental phase of this and further investigation.

This approach, however, gives significant promise toward the establishment of definite laws of the heredity of musical talent by determining the type of musical sensitivity of every member of the family whether or not an opportunity for musical expression was utilized. The value of information obtained from technique of this kind may be foreseen in its possibilities of eugenical application and prediction.

THE CONSEQUENCE OF WAR AND THE BIRTH RATE IN FRANCE

LUCIEN MARCH

La Société française d'Eugénique

As a result of the War, the France of 1914 has lost 1,400,000 of her inhabitants in the prime of life, most of them fit for producing children. On the other hand, among the survivors of the fighters of the Great War, a certain part of the 800,000 total invalids will never be able to give birth to strong healthy children, either because they are no longer capable of marrying, or because they are affected with tuberculosis or other constitutional maladies.

To these direct losses must be added the loss of births. Before the War, the number of living births balanced with a slight excess over the number of deaths; the annual number was about 750,000. During the six years 1914 to 1919 inclusive, the deficit, in comparison with six times this mean number, reached 400,000 births which ought to have survived normally, and which were lost owing to the War.

On the other hand, deaths in the civil population have been more numerous than formerly, so that 400,000 more deaths are added to the 1,400,000 missing births and to the 1,400,000 soldiers killed in war, giving a total of more than 2,000,000, taking account of possible useless counting and of immigration. These results are calculated besides in supposing that, in the invaded regions, the loss, estimated proportionally to the number of inhabitants, be the same as in the uninvaded territory; on the other hand, the numbers are applied to the territory of 1914, but Alsace and Lorraine cannot nearly fill the loss of population of this region. The provisional results of the census of 1921 confirm these suppositions.

But that is not all. Privations have broken down the health of many children born during the war or a few years before, especially in the regions of the Northeast, where, during the German occupation, they have lived in a state of veritable physical misery. Indeed, infant mortality, even in the uninvaded districts, has been notably higher during the war than before, in spite of the low birth rate.

Finally, a certain increase of alcoholism, tuberculosis, venereal disease and various nervous diseases may influence unfavorably the vitality of the nation and the race.

Many years will be necessary to repair the losses of population, direct or indirect, chargeable to war or to the evils which have accompanied it.

To avoid the unfortunate consequences of these miseries, certain people believe it is necessary to induce procreation by all possible means, and do not fear an excess of population for a long time.

Others think it proper that each man of proper age to have children have the three or four children necessary to permit a moderate increase of population. Others believe that a continued increase of population would create an economic peril and contain the germ of future wars.

Others wish certain restrictions, above all in the poorest of the population, to improve the quality of this population.

The considerations which are the most important are the following which shall be examined from the point of view of Eugenics and the point of view of Economics.

I

Today, respect of human life in all its degrees makes us condemn infanticide and abortion. There only remains, then as a means of artificial selection, the prevention of births.

But the universal concern which determines parents to limit the number of the children is the burden, at least momentarily, which the latter represent.

Also the question of the birth rate, in its entirety, and save some exception of which we shall speak soon, comes back again to a question of economic morale. For physical passion finds play without producing the being which is its end, and this being is often today the payment of a sacrifice freely agreed upon.

Humanity ought not to perish by its own error, any more than the collections which form the cells of it. Such is the higher principle which ought to reconcile itself with the practical impossibility of multiplication without limit.

According to etymology and the definition given by Galton, eugenics is a general study of the improvements of which the race is susceptible, race being characterized by common physical or mental qualities which manifest themselves in certain groups of men and differentiate them from other groups. Two ideas enter here, that of improvement, that of race. To what realities do they correspond?

We cannot define progress, the process of making perfect, but, when we look back, we feel the differences which separate the life of other times and of the present; evolution appears to us to follow a certain direction. We can then legitimately propose to continue life in this direction.

In the second place, although in a biological sense pure human races are not numerous, one can prove that a number of groups of individuals are distinguished by their physical and mental characters, apparent and distinct as a whole, from another group. Without modifying these characters to the point of making the differences disappear, one can improve their manifestations, the manner in which they act in each human group, that is the aim which Eugenics seeks. But we must not lose sight—for other sciences seek the same end, the science of education for example—that Eugenics is occupied, it seems, only with the measures capable of effects upon descendants, that is to say, transmissible by heredity or capable of operating a selection advantageous for future generations.

This science has not yet its general principles well established. It is not yet settled, it is still in a period of growth. And that permits some liberty, some differences of viewpoint to those who try to improve it.

There are however acquired facts, indisputable connections; for the present one may withdraw to this ground.

Whatever may be the opinion as to the relative importance of one or the other factor, heredity or environment—that is the principal point on which personal opinions oppose each other—one cannot deny the influence of heredity. Physical and mental resemblances of parents and children are very evident; the hereditary transmission, at least in the most closely related generations, of certain physical peculiarites, such as stature, conformation of the skull, hemophilia, polydactylism, etc., or of mental defects such as epilepsy, certain forms of mental deficiency or feeblemindedness, are today almost proven. Provided that it is always a question of the simple characters whose existence can be removed. Resemblances between children born of the same parents do not prevent sometimes great differences appearing in these children. The heredity of abilities or that of defects has nothing of fate: then education may modify nature.

As to the influence of environment on the mode of development of the created being, whatever may be its importance for this being itself, the question which interests eugenics is to know if this influence acts upon the descendants after being hidden a number of generations. On this point, certain savants, Weissman in particular, have declared negatively. Others have shown, by experiments on inferior organisms, that organic modifications performed on these organisms are transmitted to their descendants.

As Dr. Apert has remarked in France, as far as man is concerned, it seems that only the modifications relating to the nervous system have yielded, up to the present, observations truly conclusive. Yet the interpretation of these facts has been contested; they have been charged to hereditary predispositions, but it is always easy to draw into the results of an observation the effect of a hidden influence as mysterious as that of heredity.

One does not know enough to challenge on these obscure questions, and yet of such great importance to humanity is a development, sustained and growing, of scientific researches relative to the heredity of man that this is the desire of all those who are interested in eugenics.

The action of the two factors of the transmission of character, from one generation to another, works by means of germplasm, but this is guided by selection: natural selection by death, artificial selection by sexual union.

M. Edmond Perrier, the very regretted president of the Société française d' Eugénique, gave recently an opinion, that, in primitive nature, natural selection had not perhaps had the exclusive effect which the Darwinians have attributed to it.

Moreover, what precisely is natural selection? Does one understand simply that an individual incapable of adapting himself to the conditions imposed on him by environment disappears and they only survive who are capable of adapting themselves? That does not add a great deal to our knowledge, as M. Balfour (speaking before the First International Eugenics Congress) remarked, since that amounts to saying that only those are capable of surviving who survive, a veritable truism.

And if one means that only those survive who are capable of surviving, M. Perrier answers (Eugénique, mai 1921, page 197) that those who are incapable of surviving in one determined point can escape death by flight, and it is thus perhaps that at first the living world has evolved.

In truth, death and survival are a form of selection from which may result for humanity, as for every society of living beings, good or evil following the individual in the case, and surrounding circumstances.

If we are unable to modify the innate qualities of the individual, we may often, by acting upon the circumstances which surround them, make useful the qualities which they have.

This is one of the essential duties of eugenics: to favor and encourage the work of health and the work of education of promoters of social progress.

As to artificial selection, we may endeavor that the revival of man by birth shall be facilitated for those who possess the best qualities, be shackled for those who show, on the contrary, defects and faults. However, we ought to ask ourselves whether there does not exist now and then a certain

opposition to these two directions: that which leads to the improvement of conditions of existence and that which leads to the research of the best qualities in the descendants.

Opposition has been noted many times, especially among the English eugenicists. Nature, they say, in a convenient anthropomorphic language, nature has arranged itself for the beings least endowed for life discourages before those who are better endowed. This observation is just; in admitting that as to the shadowy origin of life, flight has been a means of preservation, this means is not worth much when it is impossible to flee from danger. This is the case when illnesses and bodily struggles have made disappear the least worthy beings, the least capable of resistance. But when human fraternity, pity, science, and hygiene unite their efforts to defend the weak, many individuals who would have disappeared, left to themselves, live in spite of their inabilities and transmit these to their descendants. As is often remarked, the humanitarian tendencies of our time, our social legislation and all the measures which come from the same principle, have this effect—of which people are not sufficiently warned—to oppose the play of natural selection. This manner of thinking bears a great deal of truth. However, no defender of eugenics thinks of suppressing pity, or hygiene, to reëstablish natural selection in its barbarian despotism. The efforts of humanity tends to utilize the natural forces for their own ends and not to let them act blindly. Also when the ideal of healthfulness and social progress is opposed to the ideal of perfection of race, because the first is contrary to the effect of natural selection, it becomes necessary to demand from artificial selection much more important effects, and especially those better regulated, than those which she produces among primitive people.

It is this which we will now take account of in passing to the special question of birth. Even though we can lessen the effects of natural selection, we can much more surely intervene by artificial selection to favor the perfecting of the race and above all to prevent its degeneration. The point is to make good use of this power.

II

In all times man has tried to deal with the multiplication of his race. Independently of wars, famines, epidemics, whose destructive effects extend themselves over entire populations, suppression of infants already born, abortion, and prevention of births have been practiced.

Eugenics, as well as economics, can tell us what the social interest demands, to be sure. From the point of view of eugenics, the experience

of centuries and of many researches teaches us above all that there are transmissible defects, multiplications of which must be avoided at all costs. These are notably the hereditary predispositions to insanity, to mental weakness, to epilepsy, and to detrimental malformations; or again the acquired dispositions chargeable to the poisons of the nervous system, such as alcohol and the spirochete of syphilis.

Evidently one cannot always be sure in advance of the effect of those influences which, acting in the mass, give rise to differences. Nevertheless there are individuals whose duty it is not to procreate, not to give birth to beings whose chances of deformity or mental deficiency are really too great. This duty is all the clearer when one is forced to conserve the life of those beings who, in other times, would have been condemned to a more rapid death by the brutalities of existence.

Beside the circumstances which justify and command abstinence, there are still others which can be drawn in very legitimately to limit the number of children; one understands, for instance, that, in the very crowded urban districts, the smallness of homes, the promiscuity, cause an excessive mortality when the families are large, without having means for choosing spacious homes. Finally, there are individual proprieties worthy of respect, for example, the care of the mother's health when she cannot stand numerous pregnancies, not to speak of the limits which can impose a legitimate fear of an undeserved loss, if a large family imposes a burden which surpasses the strength of this family.

One would not then accept the formula of an unfortunate equality, which would impose on all adults the obligation of having a determined number of children, any more than one would dream of recommending an unlimited fecundity. It is necessary to discard these precise but too simple formulas, and to keep within the bounds of asking that each adult of age to have children have them if he reasonably can. Each one, in fact, has the duty of transmitting the life that he has received, and even of improving the value of that life as those who have preceded have striven. And thus is imposed, according to the limits of his means and his capacities, the duty of perpetuating the family to which he belongs, the duty of contributing to the aim of his country and the progress of all humanity.

The formula is doubtless very vague, it is addressed to conscience, for it is conscience alone which is the judge of the degree to which the order has been obeyed. It is the same as when one appeals to the conscience of each one to participate in the defence of country or of national burdens.

In this case, it is true that legislation adds itself to the moral obligation: is it not necessary that legislation also intervene in favor of the birth rate?

The answer to this question is not doubtful; we cannot omit a certain social organization capable of stimulating conscience and assuring the desired result: that is to say, the number of births which appear necessary for the whole of the population.

However, two objections have been made. One declares that before increasing the birth rate it would be better to reduce mortality and, above all, infant mortality.

It is obvious that all measures capable of reducing mortality are good in themselves. But, since the remotest historical times, it has not appeared possible to lengthen the maximum of human life. We can only hope to lengthen the mean duration of life. But that will not produce an appreciable increase in the population in the countries where the number of births depends on familial foresight, when the parents determine, so to speak, in advance the number of children they will raise. Three years out of four in France, the number of births in one year is related to the number of infants who have died in the preceding. If many children die they are replaced, if there are not premature births, so many births less.

The second objection is that instead of seeking the number of children, it is preferable to concern oneself about the quality. We have seen that the quality of population is in fact the principal aim of eugenics.

But it is proper to consider successively the family and the nation.

In the family, at the time when the number of children does not exceed the reasonable limit of which we have spoken, one can affirm that quality goes hand in hand with quantity, far from being opposed to it. One has often noted the case of the only child. One has also cited examples of numerous brilliant men who are among the younger members of families, sometimes of very high rank.

As to the Nation, she may claim a certain choice, a selection, of which we have mentioned the importance in the first part of this paper.

But by what sign may inferiority and superiority of qualities be recognized, it being understood that one is to be forced to prevent from procreation the bearers of defects? It is proposed to take wealth for an index. Numerous inquiries have proven in fact that in the slums of cities, among the individuals who have no care for the morrow, are found the greatest number of transmissible defects and the most afflicted children. On the other hand, manifestations of intelligence and various abilities have appeared more frequently in the children of well-to-do families than among those of poor families.

But the influence of environment is considerable here, even as that of education. If one leaves out the small part of the population which is composed principally of social outcasts, one cannot but affirm that the innate

qualities (we do not speak of acquired qualities) are less in the families of small income than in the families of large income, especially if one takes into consideration all classes of population, city and country, intellectual and artisan.

Reserving the elimination of undesirables, it does not seem that there is serious reason, from the single point of view of eugenics, of seeking births in one class of population more than in another. The numerous statements which have been made on the retrogression or even the degeneration of families which have not renewed themselves sufficiently, tends on the contrary to provoke the incessant mixing of social classes rather than their separation. When one considers the state of the population, one perceives great differences in the birth rate. In France, the birth rate is generally greater in the country than in the city, greater in the mountainous regions than in the valleys, greater among the agriculturists, the sailors, the fishermen, colliers of the North, the heads of great industries, than in the middle classes, among the artisans and especially among the clerks. These differences explain themselves; they appear in the nature of things, and, for the moment at least, they do not carry any danger. We know that depopulation does not reach the towns which are being filled unceasingly by an influx of inhabitants from the country; it is then the birth rate in the country upon which effort should principally be brought to bear; it is there that results can be gained most easily, at the least expense and under the best conditions from the point of view of hygiene, as well as from the point of view of eugenics.

Moreover, social action ought not to confine itself to facilitating the birth of children; it is still necessary that institutions be permitted to raise children up to a certain age. Questions of education, emigration and immigration are also questions on which eugenics has something to say, especially on the question of immigration which has gained since the war an importance and character unknown in France before.

Eugenics has also something to say on the psychological and moral side of the question of birth rate. Prevention of births, regarded as necessary in a certain measure, can be recommended as only according to the means indicated by Malthus; the delay of marriage.

Fecundity of marriage, which one supposes as great as to allow the care of maintaining a healthy family well adapted to life ought not to be fettered by an excessive fear of life, or by the fear of effort. All hope of the future cannot be realized except with a certain present sacrifice. It is necessary to make some personal sacrifices and to have hope in the future.

These sacrifices will be moreover fruitful for posterity. In what measure can they be shared; what profit can they yield for it? That is what the examination of the question from the point of view of economics will show.

III

The economic power of a country depends primarily on its producers: that is to say, on those who by their work make serviceable natural riches.

Now we have seen above what is the loss of population since the war. The loss comes principally from the avoidance of marriage. During the war, many young men rightly wished to reach the end of hostilities before marrying. From that has come the increase of marriages in 1919 and 1920. The same phenomenon has been observed after all wars, it is easily explained.

But the deficit is none the less a noteworthy fact in our country and in Belgium. While the population of Great Britain has increased by 1,300,000 during the same time and that of Germany has hardly diminished; if it has diminished at all, we are still ignorant of it. We know in any case that in Prussia the number of deaths has not fallen below the number of births.

Therefore imagine the state of the French population in fifteen years. At that time, there will be lacking, taking account of the mortality, 500,000 young men of the ages of fifteen to twenty-one years, a loss which must be added to the 1,400,000 men of eighteen to fifty years of age killed during the war, and who would then be thirty-three to sixty-five years old, as well as the 500,000 young men of the same ages who have died in the civil population in excess of the normal mortality. In all, about 2,000,000 individuals would be counted in the male population to fifteen to sixty-five years, or about one-sixth of the population.

There would be lacking in consequence, about 1935, one-sixth of those whose work must furnish the principal source of income of the nation. In spite of the restoration of Alsace-Lorraine which brings us 400,000 adults of fifteen to sixty-five years, but which demands also workers for its fields and iron foundries, it is certain that the French production will be deprived of an important part of its active forces and that the economic life of the country will languish for many years if energetic measures are not taken without delay to ward off the threatening deficit.

Without doubt, one might temporarily make appeal to foreign workers; however, assimilable populations can only furnish a small part; it will be necessary to have recourse to unassimilable races very different from ours, and which will furnish quickly undesirable elements.

Doubtless also the deficit of masculine workers has caused the more general employment of women. But the women who work cannot be fruitful mothers. Feminine work will only be a short-lived mitigation.

For all time, since the infant demands care and pain, as well as the joys he brings, maternity has been a cause of care and effort. Among primitive tribes which are malplaced, it is obligatory not only to nourish but even to bear these children. In our civilized societies, and especially in urban centers, where civilization is most refined, the burden is often very heavy, the difficulties of lodging, the hindrances of traffic, the care for appearance, which is applicable to children as well as to parents, the care for the health of the mother and all the complications of urban life; the laws for working women, the educational obligations and the impossibility, in poor families, of using the work of young children, make heavy enough the maintenance of even a limited number of children.

Formerly, in poor families, who are the most numerous, the help which grown children gave to their old parents, compensated in some measure for the privations which they had caused at first. Today, collective insurance is substituted for this kind of family insurance of previous times. In consequence, the child usually never brings any repayment in exchange for what he cost. Also the care for his future invited the foresighted parents of our time to assure themselves of the excellent probabilities of his future establishment, which determines them also to restrain their responsibility. When the children may rather quickly be an aid to the family, the burden is much lighter. Also one finds the greatest number of children among the people chiefly concerned in agriculture, and, in every country, in the rural populations.

However, the first obstacle to birth is the possibility of raising the children. Doubtless this obstacle exists for many animal species and does not hinder their fecundity, but in those species there is no reasoning power, no foresight, no respect of life, at least in a degree comparable to that which may be observed in civilized human society.

A second obstacle, which does not exist in any degree outside of humanity, is the foresight of parents exercised beyond the time of growth of their children. It is not all to have brought into the world children and to have raised them to an age when they have strength enough to answer for themselves; the environment in which they are placed must permit them to live. To understand the economic mechanism of the phenomenon of birth it is convenient to distinguish three orders of circumstances:

1. The means of keeping children alive during their growth.

2. The eventual means by which these children can live by themselves after growth.

3. The opinion of parents on these future circumstances.

It is necessary to understand here by means of life, the means of leading a certain kind of life; one can say in general that it is a kind of life at least equal to that to which the parents are accustomed. Often even, the desire of the parents is that their children will reach a higher stage of life.

But the means of living are governed in part by circumstances external to living beings and in part by the circumstances which depend on these beings themselves. The analysis of these circumstances composes what is called the theory of population.

Long before Malthus, who formulated this theory, they had estimated the faculty of increasing the human species, a faculty analogous to that of every other living species, when no limitation intervenes. It is wrong to reproach Malthus with having employed the formula of geometric progression, since a simple reasoning founded on a not dissimilar hypothesis establishes it. Where Malthus appears to be mistaken is when he attempts to justify his law by experience or to deduce from one isolated experience the reason of progression. If he could have extended his observations still farther, he would have seen that this reason was not constant, and indeed, in consequence, progression was not geometric.

If on the contrary one keeps to the domain of hypothesis, as others had done before Malthus, if one supposed that nothing limits the fecundity of women, as a woman can bring into the world at least 8 children, taking account of cases of involuntary sterility and physiological mortality, it is easy to understand that in thirty years a population not meeting any obstacle would increase itself in the proportion of 1 to 4 at least: that is to say, it would be more than doubled in fifteen years.

Malthus admitted that the population of the United States doubled every twenty-five years; a more rapid progression has been cited, that of the Hebrews passing through Egypt: 70 adults became 500,000 in two centuries, which means a doubling in exactly every fifteen years, and corresponds to the period of doubling of capital placed at interest of 5 per cent a year. Every one knows what a fantastic sum is reached with a sufficient number of periods of doubling. If the doubling every fifteen years had taken place since the beginning of historic times, the men living in our time not only could not find place on earth, but would even fill the space which separates our globe from far distant stars. Therefore the hypothesis which leads to an idea of constant geometric progression is not verified by facts. In reality the matter changes with the times because of obstacles which meet the indefinite multiplication of a species, for men as well as for all living beings. The interest of the work of Malthus is that this author has classified the obstacles and made a choice.

A second error, which is often made, consists in assigning also a general law to the development of the means of existence: These can only increase by following an arithmetic progression.

This pretended law has no theoretic foundation, even in admitting that one works in a limited territory, since the production of subsistence depends on putting to work the means of production. In fact the means of existence has progressed much more rapidly in certain epochs than in others. In the nineteenth century for example, the population of the most civilized states increased more rapidly than during the previous centuries. There is then no general law to be assigned to the increase of population.

If one applies the formula which would recapitulate the theoretic movement of population, one would begin to say that population develops itself in the same measure as the means of living are developed, that there is a correlation between the two phenomena. But this vague formula is only pure tautology, since one cannot conceive of a population which would develop without means of life. Such a formula can only serve as armature for a true theory of population. In order to have a theory, one must indicate some mechanism for the relation between population and the means of subsistence.

The theory of Malthus tends to establish the fact that individuals, according to nature, have an action weaker than the reaction exercised by it. Inversely, other theorists, before Malthus the mercantilists and populationists, after Malthus the advocates of patriotic fecundity, have pretended that, in certain limits at least, man could always obtain from Nature what he needed to live. These two theories have been translated by picturesque formulae.

Where bread is born, man is born, say those who believe in blind fecundity and limited productivity. Where man is born, bread is born, answer those who measure the limitation of fecundity and have faith in the powers of invention.

In reality these brief formulae are too general: following the epochs, following the countries, natural increase of population tends to diminish production; in other cases the contrary is true.

In China, in India, the population being increased to a certain degree, a deficient production results in veritable hecatombs of human beings, after which equilibrium is restored. In other countries where patriarchal life has given place to a complicated organization founded on the division of labor and the specialization of services, the means of production increase sometimes to such a point that production surpasses the needs. In this case it is true, the conditions of existence of the people are in a mutual dependence, and this dependence gives rise to terrible conflicts.

In the human species, as in all living beings, death appears as an inflexible regulator of the interaction of the two factors of life: natural fecundity and nourishment. But, in the human species, the individuals are capable of foreseeing in some measure future events; foresight is the principal instrument of progress of the species and of civilization. Malthus has marked well this difference between human species and others, and he has declared that for the brutal regulator of other species one may substitute that of reason. That has been expressed, in rather rude form, by a German economist, Julius Wolf, who sees in the universal diminution of the birth rate the effect of increasing rationalism of a life.

Only, Malthus has not seen the importance which this factor will have and the danger which will result when this factor is capable of suppressing all the principles of life. He believed, on the contrary, that the power of instinct would always be stronger than the fear of overpopulation, and he impregnated the thought of his century with a dangerous pessimism.

But is it true that increase of population is necessarily a menace to the existence of this population? The facts answer for themselves. Not only has the nineteenth century seen the civilized nations increase in proportions unknown in the preceding centuries without these nations having suffered want: but, among them, the most rapid increase in wealth has gone with the most rapid increase in population. In England at the beginning of the nineteenth century, poor laws imposed excessive burdens on the parishes, misery ruled and the lamentable state of the population at the beginning of the age of machinery justified later, in the eyes of Karl Marx, its attacks against the capitalistic regime. Since then the production of foodstuffs has diminished, and the population has quadrupled from 9 to 36 million (1911).

At the beginning of the nineteenth century, they feared in Germany, as as much as in England, an increase of population. Measures proper for restraining marriages were even passed in the legislatures of certain states such as Bavaria and Wurtemberg. In order to have the right to marry, one had to show sufficient means. Thanks to these restrictive measures and to propaganda, the increase of population has remained very slow—slower than in France, during a great part of the nineteenth century. Thus during the period of thirty-five years, 1847–1871, the number of inhabitants increased 13 per cent in Bavaria, 9 per cent in Wurtemberg, while they increased 17 per cent in France.

Events happened which transformed the state of mind, and without doubt the faith in the future, without modifying the natural conditions of production, and the view changes. During a second period of thirty-five years,

from 1871 to 1915, the number of inhabitants increased 34 per cent in Bavaria, 27 per cent in Wurtemberg, while the proportional increase fell to 9 per cent in France.

A good element of appreciation of the activity and the power of expansion of a people is furnished by the development of its exports, or, if one considers 10 states for which one can give at the same time the proportional increase of the number of inhabitants from 1875 to 1913 and the relative progress of exports, one proves a close relation between the two movements.

Proportional increase between 1875 and 1913

	POPULATION	EXPORTS
	per cent	*per cent*
France	10	80
Italy	29	145
United Kingdom	45	160
Belgium	54	237
Russia	65	260
Austria-Hungary	38	383
German Empire	58	380
Canada	103	423
United States	138	386
Argentine Republic	330	828

The two series of numbers vary in the same direction.

IV

What is to be concluded from these results? Simply that the phenomenon is too complex to be analyzed in its entirety without tracing back to elemental facts.

Let us turn to the father of the family, for it is in fact upon the fathers of families that the birth rate of the country depends. We have said that this decision depended most generally on three factors:

1. The expense represented by bringing up a child to the time when it can care for itself.

2. The chances this child has of living effectively, at least in the conditions under which its parents have lived.

3. The opinion of the parents of this expense and these chances.

Other factors intervene also; considerations of health, well-being, etc., but we will only concern ourselves with those which are most general and least synthetic.

Do not regret that, in this grave question, reason is substituted for the most simple instincts. Let us force ourselves to see only that which commands the true meaning of things.

At the origin of the problem of the birth rate, one finds two facts of economic order and one psychological fact. This last dominates the two others, particularly the second. Add that the psychological fact only intervenes where the customs and legislation are directed by the sentiment of respect for life. For among the primitive people, abortion and infanticide excuse the parents from thinking of the future. They let the sexual instinct act freely, for they may cause to disappear the results of this action, sometimes, as in Sparta, with the illusory forethought of selecting the survivors.

In our modern society, these procedures are no longer admitted; they are supplanted by the prevention of births; that is left to the will of the parents who bear the burdens. But this will is guided by judgment and sentiment. If judgment is clear and sound, if sentiment is right, the voluntary action will be well directed. In the contrary case, it will come to evil. But the first condition, in order that the parents be not hindered by a too fearful foresight, so that they may act in a sense best conforming to the good of society of which they are a part, is that they have a certain moral force, that they know how to sacrifice a little of their personal interest to the common interest, for maternity always brings some sacrifice, at least physical, and that they have confidence in the future. One may say that the question of population is above all a moral question. A certain optimism is necessary but this optimism ought to follow from facts.

It is always imprudent to ask too much of the sentiment of duty when one addresses a whole population. During the war, when invasion roused patriotism, it was necessary to impose military service by force.

So when it is a question of the birth rate. When general education, when the comparison of military or economic power of the country shows to all families the common duty, nothing better. However, although in this matter, no sanction will be legitimate or efficacious, still it will be proper to facilitate the accomplishment of this duty.

That which concerns the care of the future is one of the legitimate preoccupations of the head of the family. The movement of general prosperity must be such as to make the establishment of children appear easy.

It is sometimes said that there are fewer children in well-to-do families than in poor families. This is true in the sense that if the income of poor families increases, the number of their children tends to diminish. But this is not really exact for all categories of rich or poor families.

Let us consider for instance the French statistics of 1906 where the families have been classified according to the number of children born in these families, whether living or dead; in the families where the marriage has lasted twenty-five years or more, the number of children per 100 families is equal to 303 among clerks and increases to 360 among their employers, 409 among laborers, more than 480 among fishermen and sailors of commerce.

If one classifies the employers of more than 25 years of marriage and aged from sixty to seventy years, one finds that the mean number of children born in 100 families is only that of 305 in the liberal professions, that it increases to 347 in commerce, 370 in agiculture, 385 in the total of industries, properly so-called.

The relative situation of employers in agriculture and industry is not the same when one considers the marriages having lasted less than twenty-five years; for the marriages having lasted less than five years, from five to fourteen years, or from fifteen to twenty-five years, productivity of the marriages is greater in agriculture than in industry. All happens as if the chiefs of agricultural exploitations, after having had a determined number of children more rapidly than the chiefs of industrial enterprise, stop sooner than the latter.

The detail of professions permits even a distinction between the groups of similar industries. The number of children for 100 married men exceeds 390 in mines and quarries, in the mining and in the textile industries, in the enterprises of building and of transportation, while it falls to 350 and below in industries of food production, book-publishing, (book-binding or printing), goldsmithing, and jewelry. Thus it appears that in the great industries the employers have more children and in the small ones fewer.

Among the commercial professions, the number of children per 100 families is greatest among the butchers; it is smallest among bankers and chiefs of financial enterprise who form a sort of transition between industrial or commercial professions and the liberal professions.

Thus, among employers, productivity seems bound, in a certain measure, to the professional characteristics, but these are rather complex: on one hand, the intellectuality of the profession, if one may so call it, a small productivity, as the number of children per family is small in the liberal professions, in the studious professions, in financial enterprises, while the manual professions have a productivity relatively higher; on the other hand, the chiefs of great industries seem to have a productivity higher than that of the small industries and merchants.

Two factors act in a quasi-independent way; on one hand the intellectual character of the professions which leads to late marriages and creates an

environment little favorable to fecundity for reasons which it is not necessary to develop here; on the other hand, preoccupation with the fate reserved for the children. In great industries, these will easily find employment for their abilities and will obtain without too many difficulties situations equivalent to those of their parents, either in or out of the country. In the little enterprises, on the contrary, and except in special instances, such as that of butcher, where the employment of the entire family is almost a condition of success, the father of the family does not look ahead, without uneasiness, to the future laid out for his children.

Certain of these characteristics will be found among the salaried clerks and the laborers.

The smallest number of children is observed among the clerks of stores, waiters in cafés, hotels and restaurants, office employes and employes of public service.

Among the laborers, the greatest productivity, at least more than 5 children born in a family founded more than twenty-five years, is among smaller laborers and workers in spinning mills.

One notes that the lace weavers, among which are a great number of weavers working at home, have a smaller productivity than the spinners (489 per 100 families against 540 among the spinners). One notes also that, in agriculture, the domestic workers of the farm, generally lodged at the farm, have 395 children per 100 families, while the field workers proper have 426.

But the industries in which the workers have less than 4 children per family are numerous. Those who have about 350 children per 100 families founded more than 25 years are makers of wooden shoes, coopers, toymakers, saddlers, tailors, printers, metalworkers, electricians, jewelers, and silversmiths, various workers in commerce, drivers, deliverymen ("livreur"). It seems that professions of smaller industries, and especially professions in cities, give the smallest figures. For the masons, day laborers, people without profession, generally occupied in the cities, one counts 464 children born per 100 families; among the workers of industrial service of the State, roadmenders, etc., the productivity exceeds 390 children born per 100 families; it decreases to 360 among the police, and customs employes, etc., to 350 for workers and under agents of the post and telegraph.

Finally, among personal servants, it decreases to less than 3 children born per family, always for the heads of families married more than twenty-five years.

On the whole, among laborers, and workers in great industries where the work is relatively regular and abundant, when the agricultural work offers

a real stability, when the dwelling is either in the country, or among industrial collections grouping the laborers of the same class, productivity is relatively high; it is lowest where the small artisans live most, in the trades carried on in cities, also where profession demands to the least degree physical force. It is also small where the persons classified as workers are confined to the category of clerks and especially where the conditions of employment, the conditions of lodging, make preferable households without children or with few, rather than households burdened with children.

From the total of the preceding statements we will remember that if the workers in general have more children than the employers there are not lacking professions where they are fewer. In the second place, for one as for the other, it is the great industries which seem more favorable to productivity, and small ones less favorable. Naturally here the influence of environment exercises a certain influence, the regions of great industry are generally other than those of small industry.

The preceding observations (the pictures shown in the exposition rooms of the Congress illustrate these observations) confirm, although not entirely, those that have often been made on the relation between fertility and social standing. This being at once the function of income and education, those are the most fortunate categories where education is the most refined, or where the number of children is the most limited. On the contrary, fertility would be greatest in the poorest environments, in those where the kind of life is the plainest.

If, in a general way, there is in this observation a great part of truth—the comparison of districts of great cities according to categories classified according to exterior signs of income show it—there are modalities which must be taken into account. No doubt, for example, that employers are generally more fortunate than their employes, and meanwhile they have notably more children than the latter. On the other hand, employes, who receive generally higher wages than laborers, have fewer children than the latter.

The question has often been studied, and it is important that new contributions be brought to it.

We will borrow for new indications recent statistics of France drawn up by the aid of family schedules filled out in 1907 by a great number of employes and workers remunerated by the budgets of the State, departments and communes (Conseil supérieur de statistique, bulletins 10 et 11 Statistique Générale de la France, Statistique des familles en 1906).

These functionaries have been classified according to the annual showing of the actual emoluments and, considering only those whose marriages have

lasted more than 15 years, the number of children born per 100 families has been calculated:

	ANNUAL SALARY IN FRANCS								
	500 at most	501 to 1,000	1,001 to 1,500	1,501 to 2,500	2,501 to 4,000	4,001 to 6,000	6,001 to 10,000	More than 10,000	Average
Marriages lasting fifteen to twenty-five years									
Clerks	277	241	259	245	223	231	239	238	237
Laborers	329	321	293	280	254	234			307
Marriages lasting more than twenty-five years									
Clerks	330	301	305	280	264	264	261	286	285
Laborers	348	363	346	329	305	240			385

All classes taken together, the numbers which precede are in accord with those which have been determined with the aid of the general census, either for clerks or for laborers or sub-agents of the public service.

Comparing now the numbers of children by classes of salaries, one will note that, among the laborers, the number of children diminishes regularly as the salary increases; among the clerks it diminishes until it reaches a minimum for clerks earning 2500 to 10,000 francs per year; it rises for clerks whose annual payment exceeds 10,000 francs.

To complete these proofs, it is proper to remark that salaries and emoluments depend in great measure on the region or settlement where each clerk or laborer lives. Change in fertility is submitted to a double influence, showing that salary only partly determined.

The influence of environment has been evident in observing in all France the families of limited classes of agents scattered in all the territory, generally in the rural communes, the roadmenders and the gardes-champêtre (rural police?).

For these agents, fertility is analogous to that of the population in the midst of which they live, greater in the regions of high birth rate, smaller in the regions with a low rate.

One has preceded with a similar research among the clerks properly so called of prefectures and mairies. The personnel of the employes (not composed of boys, guardians, laborers, etc.) has, in general, fewer children proportionately as the number of inhabitants of the city has increased. It is the same for the populations of these cities. But, if one establishes the relation between the fertility of these functionaries and general fertility, one remarks that the first is less variable than the second.

In 1901, 100 families founded more than 15 years had 199 surviving children in Paris, 228 in cities of more than 500,000 inhabitants, 266 in the smaller cities. Among the administrative employes, the corresponding numbers are 183, 198, 215, or 92 per cent, 87 per cent, 81 per cent of the preceding. Employes have in some degree a specific fertility which depends less on environment than that of laborers.

One obtains results analogous to the preceding, when one determines the proportional number of sterile families.

Among the marriages having lasted more than 25 years, the number of sterile marriages to 1000 marriages varies as follows, showing the annual income:

	ANNUAL SALARY IN FRANCS							
	Less than 1,000	1,001 to 1,500	1,501 to 2,500	2,501 to 4,000	4,001 to 6,000	6,001 to 10,000	More than 10,000	Average
Clerks	95	86	99	113	101	111	109	101
Laborers	70	74	91	98	100			78
Proportional number of families having had more than 7 children								
Clerks	56	53	41	33	26	23	52	44
Laborers	95	86	75	55	50			88

On the whole, the statistics of French families permit one to see in what measure fertility is bound up with the social situation. Numerous factors intervene: for instance, the chiefs of enterprises in the most industrial regions of the country: the North, the region about Lyons—have many children, more children per family than many other less fortunate classes. Among the laborers, the miners of Pas-de-Calais have likewise many children in relation to other laborers. In these two cases the parents have no fear as to the future of their children. The great employer knows that he can easily establish his; the mine laborer knows that there will always be work in the mine for his.

This sentiment becomes general when one perceives continued progress everywhere, in the agricultural, industrial and commercial movements, and in the action of public powers in favor of education, apprenticeship, exportation, emigration, great works.

Confidence in the future is then assured. It is this factor which seems to have played an important rôle in Germany after the constitution of the Empire and the war of 1870. But the two factors which we have just considered, a certain courage on the one hand and a certain optimism on

the other, do not suffice always; it seems useful to ward off at first the obstacles which we have recognized, that is to say, to lighten the burdens which the maintenance of children cause parents.

Here it is proper to proceed with method. Since it is a question of financial participation, it is expedient to place the effort where it is most necessary and to seek to obtain the maximum result from the sums used.

It is humane to seek that the children brought into the world be raised under the best conditions for health.

It is good not to go against the natural course of things to limit oneself to bringing simply the spark which puts the fire to the pile.

V

These considerations tend to favor the birth rate in the country. It is there that depopulation is raging, not that the birth rate is less elevated than in the cities—the contrary is true—but because of the emigration from the country to the city.

One notices this when one compares the movement of the number of inhabitants in the French censuses of different periods, either in urban or rural population.

In 1856 the rural population was 26 million of the 36 million inhabitants in all France; in 1911, the number has fallen to 22 million, while the total population had increased to almost 40. Also the urban has been considerably augmented, passing from 9,800,000 inhabitants in 1856 to 17,500,000 in 1911; it almost doubled. It has doubled also in the class of cities of more than 10,000 inhabitants.

It is useless consequently to seek to increase the population of cities by artificial means since they increase so rapidly alone, until there is a veritable overcrowding in great cities. But it is necessary to increase that of the country for reasons of hygiene. social stability, good economy also, for it is there that children cost least.

It is there also that the birth rate is already the highest, where one will find families best disposed to have numerous children. One states that the birth rate increases in proportion to the altitude. But, in France at least, it is from the high altitudes that have come the strongest current of emigration.

Children cost much less to raise in the country than in the city; it is in the country that poverty is the most disquieting, which ought to interest the farmers to assure themselves of the number of children capable of aiding them by their work; it is there that the growth of children takes place under the best conditions of health, especially if a system of maternal education

is instituted; it is there that one is near the foundation of the population, and where marriages are made with full knowledge of antecedents. Even as one rejuvenates trees from the stump, so the renewing of the population, necessary to combat retrogression, ought to be worked from the base. The best always come from a vigorous stock, as the best fruits and the most beautiful flowers spring from well grafted roots. In the cities, national effort ought to tend to improve transportation to facilitate rapid communication which will permit the largest extensions outside the crowded areas.

In France a law of July 14, 1913, gives to every family which has at least three children less than thirteen years a monthly allotment for each child beyond the third under thirteen years, while the child is living and has not reached the age of thirteen years. The communes, the departments and the State share the expense.

Another law, that of June 28, 1918, gives an important share of the state (power) to the departments which allow encouragements to birth. This participation varies in inverse ratio to the richness of the department and in direct ratio to the number of families having more than four children. It carries at the same time the useful premium for the maintenance of children and the premium of foresight destined to assure a life-annuity to old parents or a capital to grown children.

In cities and industrial centers, numerous patronal associations have been formed to assure to laborers and clerks allotments varying according to the number of children. The treasury is kept filled by payments of chiefs of enterprise proportional to the salaries paid by each one of them. Thus the industrial has no interest in employing a bachelor any more than the head of a family.

The employes of the State and those of great private enterprises receive the same family allotments added to their salaries.

Finally, the fiscal legislation assures important exemptions to heads of large families and a surcharge to bachelors and families without children. The tariffs of income tax—impôts cedulaires et impôts globa—take account of the number of children; impôt globa surcharges the bachelors as well as married men without children. The inheritance taxes grant reductions according to the number of children living or represented, and surcharges when the defunct has left no children. Reductions are given on the railroads to members of families which have many children.

A severe law has been promulgated, July 31, 1920, against abortion and the sale of contraceptive measures.

An important movement thus exists in France which cannot but be favorable to increasing the birth rate. None of the measures adopted offer dispositions contrary to the legitimate exigencies of eugenics.

Let us add that the struggle against tuberculosis and the effects of venereal disease have gained much activity since the war; numerous dispensaries have been erected, to such a point, that in spite of the increase of these diseases, one cannot find, as might have been feared, an increase of the special disability of children, excepting naturally those who were born or who passed their childhood in the regions invaded by the enemy.

The decline of the birth rate is a phenomenon which has shown itself in a great number of countries. The intensity of the movement is very different in different States; its effects depend, in great part, on the long or short duration of time since the phenomenon commenced to appear. The causes are almost the same everywhere; the means of combating the causes are not known to be very different, although the action of moral influences depends naturally much on general mentality. As to the other influences, the experience which has been had in France cannot fail to be instructive for all nations and for all those who are interested in this still conjectural science known as Eugenics.

THE EFFECTS OF INBREEDING ON GUINEA-PIGS

SEWALL WRIGHT

Bureau of Animal Industry, United States Department of Agriculture, Washington, D. C.

An experiment on the effect of inbreeding, using guinea-pigs as material, has been carried on since 1906 by the Bureau of Animal Industry of the United States Department of Agriculture.

Twenty-three families of guinea-pigs were maintained for a number of years by mating exclusively brother with sister among the descendants of twenty-three original pairs. In sixteen cases both of the original parents came from a stock which had already been maintained for twelve years without the infusion of fresh blood, by the Experiment Station of the Bureau of Animal Industry. In the remaining families the original females came from the above mentioned stock, while the original males were purchased from a local dealer.

In 1911 a number of animals were selected from the stock of the Experiment Station to start a control experiment. The mating of even second cousins has been avoided in this stock, which has been called Experiment B.

Eighteen of the inbred families were still on hand in 1916, having then on the average about eleven generations of brother-sister matings back of them. At this time most of the families were disposed of in order to make room for cross-breeding experiments and to obtain larger numbers from the five families which it was decided to retain. These are families, 2, 13, 32, 35 and 39. They were retained in part because they already occupied many pens, but largely because of the possession of contrasting characteristics in size, fertility and coat pattern. Each of these families is at present very homogeneous in heredity. Family 2 is descended wholly from one mating in the sixth generation of inbreeding. Families 13, 32, 35 and 39 come from single matings in the seventh, eleventh, twelfth and eighth generations respectively.

The total number of animals involved in the experiment on inbreeding and cross-breeding has been about 35,000.

THE EFFECTS OF INBREEDING ON VIGOR

It is noteworthy that there has been no very obvious decline in vigor, although the families are now on the average in the sixteenth generation

of brother-sister mating and one of the most vigorous (no. 35) has reached the twenty-third generation.

There has, however, been some decline in vigor in all respects which have been studied. The decline is most marked in fertility, including both frequency and size of litters. It has been so great in this respect that it would have to be recognized even though the decline in other respects were assumed to be due wholly to less favorable environmental conditions.

That there has been a real genetic decline in the inbred stock in all elements of vigor is shown by comparison with the control stock B, which has been superior in every respect. Still better evidence has been obtained by comparison of the inbreds with the young from crosses between the different families raised at the same time and under the same conditions.

THE EFFECT OF CROSSING

In interpreting the effects of crossing, the characteristics which depend on the hereditary make-up of the young must be distinguished from those which depend on the dam or sire. In studying these questions, inbred females have been mated with inbred males of another family (experiment CO) and with crossbred males (experiment CA). Crossbred females have been mated with brothers (experiment CI), unrelated crossbred males (experiment CC) and inbred males of an unrelated family (experiment AC).

Size of litter appears to depend wholly on the dam. There is little or no improvement in the experiments in which the dam is inbred (CO, CA). There is, however, a marked increase, 28 per cent, in the litters produced by crossbred females of experiment AC.

In experiments CI and CC in which the dam was also crossbred, there was an increase, but a smaller one (10 to 14 per cent). The influence on size of litter, of the greater frequency of litters in these experiments, is believed to be responsible for the smaller increase then in experiment AC.

The frequency of litters depends to a greater extent on the sire than on the dam. This is shown by the greater increase in frequency over the inbred stock when a crossbred male is mated with an inbred female (CA) as compared with the mating of an inbred male with crossbred female (AC). Experiment CA produced 19 per cent more litters per year per mating than the inbreds, while AC produced only 9 per cent more. When both parents are crossbred there is a still greater improvement (36.1 and 33.3 per cent in experiment CC and CI respectively).

The percentage of the young born alive depends almost wholly on the dam. There is little or no improvement in experiments CO and CA, but

an increase of 6 to 8 per cent, where the dam is crossbred. The percentage which are raised to 33 days of age of the young born alive depends both on the dam and on the heredity of the young. There is a marked increase, 9 to 12 per cent, in all of the crossbreeding experiments mentioned above.

Somewhat similarly, birthweight depends largely on the dam, while the gains between birth and thirty-three days depend to a considerable extent, though far from wholly, on the heredity of the young. Guinea pigs become independent of the dam at a very early age. There is an increase of 2 or 3 per cent in experiments CO and CA, but one of about 7 to 10 per cent where the dam as well as the young are crossbred. In the gain between birth and thirty-three days, there is an improvement of about 13 per cent in the first cross, which is somewhat increased in the young produced by crossbred dams. There is an increase of 12 per cent in the adult weight in the first cross (CO). This increase is lost where the parents, though crossbred, are brother and sister (CI). The influence of the dam does not appear to extend to the adult weight.

A loss in the improvement brought about by the crossing becomes apparent in the second generation of inbreeding following a cross (experiment C2) in those cases in which it is not apparent in the first generation.

COMPARISON OF DIFFERENT FAMILIES

A comparison of the different inbred families with each other has revealed persistent differences in color, pattern, tendency toward polydactylism, tendency toward production of monsters, mortality among the young, weight and both elements of fertility. It was found that the differences in these respects could not be interpreted merely as differences in general vigor. Vigor above the average in one respect was as likely as not to be found associated with a subnormal record in another respect, the correlation between the records of the families in two respects coming out in most cases substantially zero.

EXPLANATION OF THE RESULTS OF INBREEDING AND CROSSING

These results harmonize well, on the whole, with those found by other investigators. It is believed that they can be explained as consequences of the current theory of heredity without recourse to the rather mystical ideals which once prevailed in regard to inbreeding. There appear to be independently inherited factors which affect frequency and size of litter, ability to bear the young successfully, vitality and growth as well as for color, pattern and the other characters in which the families differ. There

seem to be surprisingly few factors which act on all of these characteristics. The concept, hereditary vigor, thus becomes merely an expression for the sum of a number of independently inherited qualities and not an entity.

The factors which cause reduced vigor in any respect appear to be in general recessive. The primary effect of inbreeding is to render homozygous a random group of the factors present in the original stock. Some combination of factors, good, bad and indifferent, thus becomes fixed in each inbred line. As the recessive factors, tending toward lack of vigor, are as likely to become fixed as the dominant ones there is on the average a decline in vigor in each respect. Moreover, owing to the likelihood that many factors for vigor will be linked genetically with factors causing weakness, it is to be expected that vigor in all respects will be found in very few lines, even where there is careful selection. In the present case, there was very little conscious selection but a considerable amount of natural selection was, of course, unavoidable.

On crossing two inbred lines, each, as a rule, supplies some of the dominant factors lacking in the other, with the consequence that there is increased vigor in so far as the character in question depends on the heredity of the animal itself. In the next generation, if brother-sister matings are made, there should be a decline as compared with the first generation in characters which depend wholly on the animal itself. The decline from this cause may, however, be balanced or more than balanced by the improvement due to the influence of the crossbred dam.

IS INBREEDING INJURIOUS?

HELEN DEAN KING

The Wistar Institute of Anatomy and Biology

There is a widespread belief that close inbreeding is necessarily injurious, and that it leads to a loss of body size, of constitutional vigor and of fertility, accompanied by a greater susceptibility to disease and by a tendency to malformations.

If we seek in the older literature for the basis of the prejudice against inbreeding that has existed for many centuries we find much that is myth and superstition, very little that has scientific value today. The first serious attempt to study this problem was made by Charles Darwin ('78) who inbred various species of plants during a period of eleven years. Darwin's work aroused much interest among zoologists and led to several series of inbreeding experiments with mammals, of which the most important were those of Crampe ('83, '84), and of Retzima-Bos ('94) with the rat. The results of all of this work seemed to justify the prejudice against inbreeding, and for thirty years have been the classic examples of the harmful effects of this form of mating.

With the recent development of the science of Genetics there has come a renewed interest in the problem of inbreeding, and during the past few years a number of important investigations have been carried on which show that there is no physiological law forbidding inbreeding and that the results obtained, whether good or bad, can readily be interpreted according to Mendelian laws.

For some time I have been conducting a series of inbreeding experiments with the albino rat, and I desire to give a brief account of this work in order to show the effects of close inbreeding in this animal when the experiments are carried on under controlled conditions for a relatively long period of time.

The experiments were begun in 1909 with a litter of four albino rats, two males and two females, taken from a stock colony maintained for research purposes. From these two pairs of rats two lines of inbred animals have descended that have been kept under the same conditions of environment and of nutrition and continued for forty generations through the mating of brother and sister from the same litter, this being the closest form of in-

breeding that is possible in mammals. At the present time the record for this series comprises some 7000 litters containing over 50,000 rats.

There has been a very rigid selection of animals to be used for breeding purposes throughout the course of this investigation. Small, weak, defective individuals have been eliminated, either at birth or before reaching sexual maturity, and only the largest and most vigorous animals in the large number available have been used to continue the inbred lines.

The first six generations of these animals showed all of the characteristics that are popularly supposed to result from close inbreeding. There was a steady decline in the vigor of the animals in succeeding generations; many females were sterile, and those that did breed produced small litters that contained many stillborn young; most of the animals were undersized; and a number showed malformations, particularly deformed teeth. These results agreed with those obtained by Crampe and by Retzima-Bos, and seemed to indicate that in the rat close inbreeding soon leads to marked physical degeneration (King, 18).

Fortunately for this work it was discovered that the stock albinos in the colony that were not inbred were exhibiting the same evidence of degeneration as the rats in the inbred strain. It was obvious, therefore, that the unfavorable condition of the animals could not be due to inbreeding alone. We found that the rats were suffering from malnutrition due to the character of the food they received. When the food was changed there was at once a very decided improvement in the condition of the rats: they gained in size and in weight; there was a marked increase in fertility and in general vigor; malformations soon disappeared, and not to exceed a dozen abnormal individuals have been found among the many thousands of inbred animals that have been born since that time.

Since inbreeding is believed to have its most marked effects on body size, on fertility and on constitutional vigor, these are the characters that will be considered mainly in summarizing the results of these experiments.

In each generation after the seventh the individuals in from three to five litters of each of the inbred lines were weighed at stated intervals from birth until they were fifteen months of age. As controls for the inbreds, series of outbred stock Albinos were reared at various times under the same conditions of nutrition and of environment as the inbred rats, and they were weighed at the same age periods.

Figure 1 shows graphs for the growth in body weight of males belonging in the seventh to the fifteenth generations of the inbred strain, and for males in the series of outbred stock controls.

During the first month of postnatal life there was little difference in the rate of growth of the inbred and of the stock animals, but after this time, as figure 1 shows, inbred males increased in body weight much more rapidly than the stock males. When the animals were at their prime, at about eight months of age, the inbred males were about twelve per cent heavier than the control males.

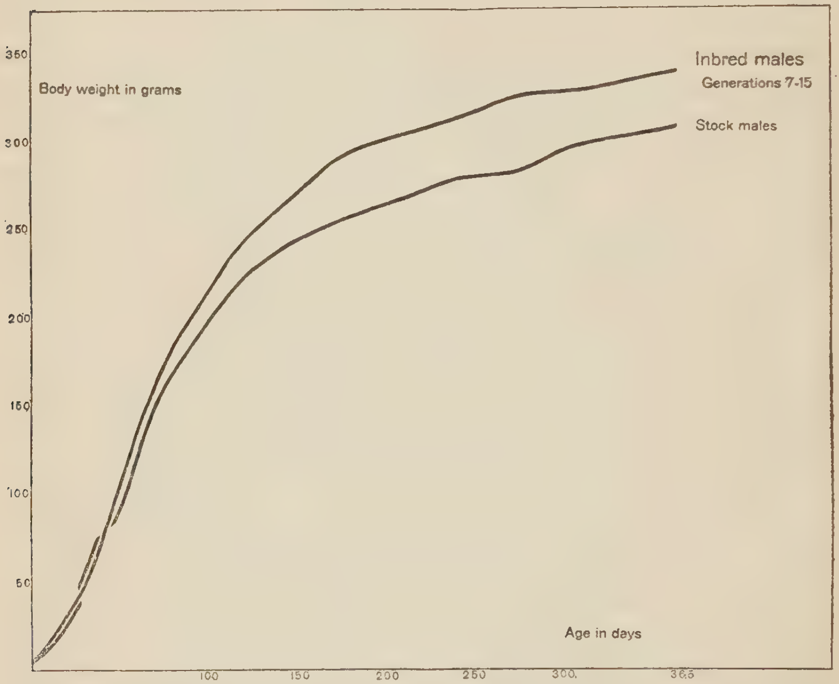


Fig. 1. Graphs showing the weight of the body with age for 156 males belonging in the seventh to the fifteenth generations of the inbred strain, and for 50 males in a series of stock controls (Data: King, '18).

The female albino rat is normally a much smaller animal than the male of like age and is less variable in body weight. Figure 2 shows graphs for the body growth of inbred and of stock females that belonged in the same litters as the males whose growth graphs are given in figure 1.

The graphs in figure 2 show that in the adult state females in the seventh to the fifteenth generations of the inbred strain were heavier animals than the females in the control series, although the difference in weight at any age period was not as great as in the case of the males.

The present status of inbred animals as regards their body weight at various age periods is shown in figure 3 which gives graphs for the body growth of males belonging in the thirty-sixth to the thirty-eighth generations of the inbred strain and for males in the series of stock controls.

Inbreeding has not, as yet, decreased the body size of these rats to any appreciable extent, since the course of the graph for the body growth of males in later generations of the inbred strain runs practically the same as that for the males of the earlier generations (cf. figs. 1 and 3). For some unknown reason this series of stock controls was inferior to the general run

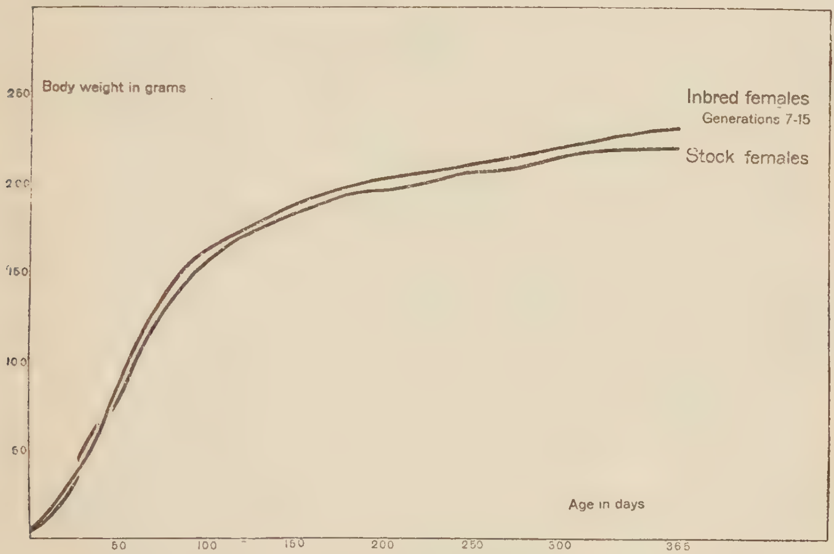


FIG. 2. Graphs showing the weight of the body with age for 169 females belonging in the seventh to the fifteenth generations of the inbred strain, and for 50 females in a series of stock controls (Data: King, '18).

of stock Albinos, both in body size and in fertility. The average body weights of adult stock males at various age periods were about 20 per cent less than that of inbred males of the same age (fig. 3). Graphs for the body growth of the females in these two series would show that the inbred females were much heavier animals than the controls at every age period.

The fertility of the animals in the inbred strain can best be shown by comparing the average size of inbred litters with that of litters cast by out-bred stock females reared under the same environmental conditions as the inbred rats.

In the first twenty-five generations of the inbred strain, as table 1 shows, the litters contained an average of 7.39 young, while the litters of the stock controls averaged only 6.75 young: In the twenty-sixth to the fortieth generation, with the data for the last generation incomplete, the inbred litters were as large as those in the earlier generations, but the litters of the control series were relatively much smaller. In the inbred strain as a whole, therefore, there has been no marked decrease in fertility as a result of con-

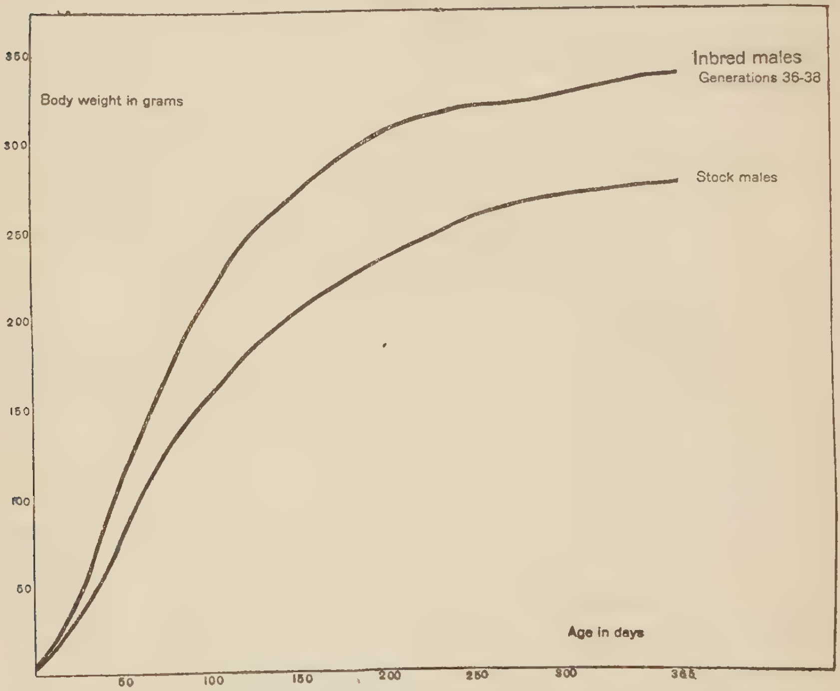


FIG. 3. Graphs showing the weight of the body with age for 89 males belonging in the thirty-sixth to the thirty-eighth generations of the inbred strain, and for 109 males in a series of stock controls.

tinued close inbreeding, and the litters have been larger, on the average, than those of stock Albinos reared as controls.

The so-called constitutional vigor of any animals may be tested in a variety of ways: for example, by agility and by mental alertness, by longevity and by ability to resist disease. In the two latter respects inbred rats compare very favorably with stock animals, Psychological tests showed that inbreds of the early generations that were suffering from malnutrition

were very inferior to stock animals, reared under more favorable environmental conditions, as regards their ability to form and to retain habits (Basset, '14), and autopsies showed that these rats had a very low brain weight. Inbreds of the twelfth to the fourteenth generations were found to have a normal brain weight and to be but slightly inferior to stock animals in their behavior reactions (Yerkes, '16; Utsurikawa, '17). No tests have been made of animals in later generations of the inbred strain, but autopsies of a number of individuals of the thirty-eighth generation showed that 75 per cent of them had a brain weight heavier than the standard weight for stock animals of like age.

The results of these experiments, taken as a whole, indicate that in the rat, inbreeding is not necessarily injurious, even when continued for forty generations of brother and sister matings—a period that, assuming three generations to a century, would cover 1300 years of human life.

TABLE 1

Showing the average size of the litters in series of inbred and of outbred albino rats

INBRED ALBINO RATS				OUTBRED STOCK ALBINO RATS		
Generations	Number litters	Number individuals	Average number young per litter	Number litters	Number individuals	Average number young per litter
1–25	1898	14,029	7.39	260	1756	6.75
26–40	2047	15,084	7.37	254	1583	6.23
1–40	3945	29,113	7.38	514	3339	6.49

Mendelism has shown that, under normal conditions of outbreeding, characters which are favorable for the species tend to dominate in heredity those which are harmful. The genetic factors for the injurious characters persist in the germplasm from generation to generation, however, and bring out the latent, undesirable traits whenever conditions permit. Outbreeding, therefore, tends to hide defects but it does not eliminate them.

Inbreeding invariably brings to light the latent characters that were hidden by outbreeding: it cannot, from its very nature, introduce any new characters into the stock. Since the constitution of individuals produced by inbreeding depends upon the chance segregation and recombination of genetic factors already existing in the stock when the inbreeding was begun, some inbred individuals will exhibit the latent, undesirable traits previously hidden by outbreeding: others will show favorable qualities. Random matings in such an inbred stock will not suppress the undesirable traits; but if only the superior individuals are allowed to breed, the unwanted

traits in the stock can gradually be eliminated if linkage does not exist, and they will not reappear unless through mutation, since the germplasm of the stock will no longer contain the genetic factors upon which these traits depend.

Inbreeding, with selection, thus becomes a powerful agent to purify a stock, to bring about a concentration of desirable traits, and to eliminate serious defects. It is through inbreeding, combined with skillful selection, that the most celebrated breeds of cattle, of sheep, of horses and of dogs have been evolved.

In spite of his great superiority, man is subject to the same laws of heredity as the rest of the organic world. Not only feeble-mindedness, epilepsy and insanity, but also general mental efficiency and marked ability in music, in art and in literature are undoubtedly transmitted from generation to generation according to the same Mendelian laws that govern the inheritance of the color of the hair and of the eyes (Davenport, '11). The effects of consanguineous marriages on the offspring of man can also be explained by Mendelian laws as readily as can the effects of inbreeding in lower mammals.

The germplasm of man, as it is constituted at the present time, probably contains genetic factors for a large number of latent defects. In the marriage of non-kin these defects, as a rule, remain hidden in the offspring, since genetic factors for the same defects are not usually present in the germplasm of both parents and therefore the normal character dominates the defective. The danger in the marriage of near kin lies in the possibility that the germplasm of each parent will contain factors for the same defect. Under these conditions the offspring gets a double "dose" of the trait held by both parents in common and therefore shows the defect, often in an intensified form. If, however, the same congenital defect or undesirable trait does not appear in the three previous generations of two cousins, including collaterals, there is no more danger that the offspring of such marriages will be defective than there is danger of the appearance of defective children in any family (Davenport, '11).

History teaches that the prejudice against consanguineous marriages that has persisted from the beginning of the Christian era until the present time did not exist among the early nations, and that such marriages were common for many centuries among the Greeks, Phoenicians, Jews, Peruvians and Egyptians. One of the longest of known human pedigrees, that of the royal Ptolemies of Egypt, is noted for its close inbreeding, brother and sister marriages being very frequent. There is no evidence that consanguineous marriages were injurious to any of these early nations. The decline of the Greeks and of the Egyptians came when they ceased to be

an exclusive people and the strength and vigor of the race were sapped by vices and luxuries introduced from other countries.

In the present status of society there is but little thought for the well being of the generations yet to come. Marriages are practically unrestricted; known transmittable defects in families are usually ignored: and the unfit are freely allowed to reproduce their kind and add to the increasing number of defectives that are a burden and a menace to the state. Laws forbidding consanguineous marriages are therefore both desirable and necessary, since there are comparatively few families that are known to be free from serious hereditary defects.

Sometime in the future an enlightened people will appreciate the value of favorable mutations and of combinations of genetic factors that produce unusual ability, and will endeavor to implant them in the race through consanguineous marriages, just as the expert breeder of today has taken advantage of the appearance of desirable traits and fixed them in his stock through the skillful use of inbreeding and selection. When the time comes that marriage is based not only on the physical fitness of the individuals but also on their recorded pedigree for several generations, and is absolutely forbidden to the unfit, the surest way of improving the race will be through consanguineous marriages in families in which the members show exceptional mental and physical endowment in ways that are of value to themselves and to the community at large. Many of the ills to which man is at present subject, for example epilepsy, will then vanish; superior and desirable traits will appear in an ever increasing number of individuals and in time become the heritage of the race.

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INTERMARRIAGE OF BLOOD RELATIVES IN THREE OLD NEW ENGLAND COMMUNITIES

RUTH MOXCEY MARTIN

Woodbury, Connecticut

The town of X——— is one early colonized from England. Some eight or ten families were the original settlers. They were of the typical sturdy pioneer sort, with the love of home, a pride in family and during the Revolution a marked tendency to be British sympathizers (though not all were out-spoken Tories).

X——— is a coast town so situated that both fishing and wooden ship building are practicable. These pioneers were compelled to be their own tradesmen, their own agriculturists, etc., in true pioneer fashion. Today one finds the fine old names in all trades and occupations in the town. It matters not whether you be a barber or the editor of the town paper, the boarding-house keeper or acknowledged hostess with weekly "at home" day—if you bear one of the original settler's surnames you belong. The boarding-house mistress, if her name and blood be of the elect, may serve boiled dinner to any number of day laborers, rank outsiders though they be, and yet later be of those who sound the old iron knocker to have afternoon tea with the judge's wife at the big house at the end of the street. Today, as before the Revolution, the bulk of the surnames of the town are confined to the eight or ten original when the grant was settled. This shows what records and townspeople affirm to be true that intermarriage has been marked.

There are today many inhabitants with incomes, many intelligent and delightful people. The town can show many graduates of well-known universities, colleges and metropolitan conservatories of music. There is a noticeable heredity of musical skill frequently linked with erratic temperament. There are writers of verse and prose; various men of unusual interest in some of the finer arts of civilization. Instances are: one townsman with a marked passion for modeling in clay and another had achieved noticeable success as a naturalist. But in this town so proud of ancestry, so certain that blood and only blood counts, there lurks a certain dread, a fear which you can call out at will in the faces of its townsmen if you talk with them of their genealogy. Possibly a conversation with an old sea captain will

give as vivid a picture of this as any lengthy set of statistics. He is a man noted in his town for quiet, pleasant ways, even normal in his life and reasonable success.

"So you wish to hear all about my family from the first of the name who settled here and you wish to know what traits of ours have come down through the generations!" Then, with a bitter curl of his fine lips (he knew the town clerk's records had been well canvassed) "I might just as well be frank at the first. I suppose the principal thing this house over your head has seen (and it has been the roof tree of six generations of my ancestors) is suicides. Nor is this house the only one hereabout of which it would be equally true." Then with a keen look at the field worker, "Had you heard this is called suicide town? Is that what brought you here? Well, for towns about it is how we are known. My grandmother hung herself in the attic here; her father, his sister, one of my own uncles, two aunts on the other side of the house, and one of my brothers all left this world because they willed to. You can find it set down over there in the town records. Yes, yes, it is suicide town!"—and his whole bearing showed the oppressing weight of such facts to his finely sensitive and doubtless somewhat morbid nature. For a moment we were silent. Then once more in answer to the question as to what in his opinion caused this, he began to speak. "What did it? How came it? Pride, miserable pride, that's what and I've been brought up to it and I feel it and most of the time I just take it for granted. But I've thought and thought. Years and years ago it was just the same. I've heard my great grandfather say it and other old people and folk in the family on down, that no families along this coast were anywhere near of so fine blood as we. (I mean in any of the little towns.) They believed it and lived it only to their own and our undoing. 'Remember blood tells' and from children we were made to know that no one was good enough to marry who wasn't a B——— or an L——— or ——— (and he proceeded with the list of surnames before referred to). I've heard that years ago when young folks ever did marry outside it was made so miserable for them that they left the town in time. First of all it was to keep property here. They had something when they came here, our sires. There is old table silver and such here in town yet to show they were real fine folk. Then after they'd done so a few generations it was the thing to do. We here did marry in with one town just south but some of our folk had brothers or cousins there and so they'd do. But again, that was marrying our relation and no good came of it. I'm related to nearly everybody in this place for ten or fifteen miles in every direction. Of course we don't call all of them relatives now in this day. But it is true

that the same blood from various families is in all of our veins and look at us. Lots of us up there on your hill (referring to the State Hospital for the Insane), lots more of us in the graveyard and we don't talk of how we came there but the town records tell the story, lots more of us (not me especially, but men and women living here today) who think perhaps it is the only way to do—stop living when you're better than everybody else on earth." He continued to insist that propinquity, tradition, inertia and in the present times decadence and in some cases actual degeneracy all tended to continue the pernicious custom of intermarriage, of selection of mates among neighbors' families, and so among blood relatives.

In sharp contrast to this town of X——— is the town of Y———, in another state, yet also seaboard in its location. Tradition says and town records, in so far as their incompleteness testify, point to the truth of tradition, that the first settlers of the prevailing surnames were a group composed of a certain wandering, roistering, loafing, sea-going helper on fishing vessels coming from "somewhere south," his coarse, feeble-minded primitive wife and certain relatives or "pals" of theirs who came with them to this port. Some tales have it that this man was an ex-convict. This hermit inlet where they could fish, dig clams, get out and in with small boats, gather berries inland, loaf generally and still manage to exist suited them exactly. To this Lotus-land they gradually attracted people of their own sort. Not *too* many others, for they jealously guarded a spot where they could make a living so easily and if too many had come in they might have had to bestir themselves—the berry fields would not have been inexhaustible.

One of the field-workers' chief sources of information was the local station agent. Not that the community itself has a railroad. No, indeed, but some miles from the dwellings is the stop at which you arrive by train and from which you must journey afoot or by conveyance of your own provision to reach the actual group of cabins and hovels of Y———. In charge at this depot is one of the men who is by blood, birth and residence a man of Y———. His only claim to exemption (and it is a great one) is some brains, a reasonable honesty and, probably more from his job than through his not-to-be coveted heritage, an ability to meet a stranger with a degree of frankness. "They are all my kith and kin" he said simply, "but to tell you truth if I want to keep anything over night I don't leave it in my back-yard nor anywhere but under lock and key in my own house." This seemed to him to stand out as a marked trait of this community composed of his kinsfolk.

Field work in the town, including calls on a minister and a doctor who lived on the outskirts, confirmed this statement. Petty thieving, or better stated, an utter disregard of property rights, save out of fear of the owner's fist, was a glaringly evident trait. The clergyman refused to open his mouth. He was not of the community he said, but he "hoped to save their souls." He knew what they had done to his predecessor after a write-up of this village had appeared in the Sunday morning edition of a large city paper —this just after a murder from a drunken brawl in which one of the citizens of Y—— was prominent. He didn't care to have the church and his dwelling burned to the ground and he didn't blame the folks for not wishing to be made talk of. He saw no point to all this investigation; it was his business "to preach on Sunday, marry 'em and bury 'em" and "like Paul I know nothing but good of my people"—he was somewhat "set" and the field-worker later discovered that his wife was "one of the tribe" though of the less undesirable of them.

The doctor who ministered to their bodies, though seldom, as he said "It's their heads mostly, those can't be fixed and they don't care to have them," was communicative. They are as a town, he averred, amazingly free (considering their un-morality) from venereal disease. He believed that was because they mostly kept to themselves not mingling much even with the lowest of towns about. Incest was not unknown; mating of close relatives frequent and general, matings "without benefit of clergy" common, promiscuity in sex relations before marriage from puberty on very general, and shifting about of consorts after marriage not at all astonishing.

Another physician in a neighboring town informed the field-worker that he was sent for in an obstetrical case to call upon Jim ———'s wife. He went, delivered her of a child. In a year or two he was called to the same duty for Dan ———'s wife. The woman he found was the former wife to Jim. A year or so later he was again called and again for confinement to the abode of Jim, where again he found the same woman. This time the physician commented and his patient said, "Well, doctor, I've tried 'em both and I like Jim the best" and so she lived strictly with Jim from that time on.

A handful of surnames, the same ones, as town records show, from the colonial times to the present day have been the chief and almost the sole ones of the town. This in itself proves intermarriage has been the rule. If anything better has come in, it has been covered and lost. These names in larger towns about are almost without fail the most frequent on pauper lists. As selectmen in two towns stated "They get in somehow and when winter comes they are on our hands for coal and supplies. They are cute,

they try it time and again. If they don't work it one place or one way they do another. They usually take care of themselves summers and then we just don't let them die off winters and that's what would happen if we drove them all back into Y———."

Some of the younger ones aged from twenty to thirty do work at times in shoe factories in neighboring larger towns. But after thirty years or so their manner of life, their feeble-mindedness, their unstable physiques, their willingness to "set about" show. They look like old men and women, at least as if they were well on in middle agedness and the younger ones bring home to them, if dire necessity drive them to such straits, some "cobbling" or certain parts of shoe work which can be done at home with a last and hammer from shoe factories of other towns. They have no trolley, they trudge in all weathers when trudging must be done; no electricity, no water save a few wells and brooks that run to the sea. They never have an abundance of food. They seldom have enough. They prefer hunger to work and possibly they think little of meal time sav e when hunger calls.

The circus, the cheap seaside resort with its ferris wheels, its targets for prizes, its petty gambling concerns, all are marks for their few pennies or a place where they may do some drudgery to pay their way in. As movies have come into towns about they do go some to them but always to the cheap ones.

Their sex appetite is appeased from adolesence on and early in life they are learned in this lore. They are not especially immoral, but markedly unmoral. They respond to their sex desires, which are noticeably unsuppressed, as naturally and freely as any animal. Physicians who attend them grant sex activity is, for the community as a whole, one of their few interests. Save for a few who seem exceptionally over-sexed, especially erotic, they do not appear to take an indecent attitude toward this part of their lives.

The mother of twelve pointed to the eldest, a girl of fourteen, and said "she helped me take this last babe at birth. I could have waited on myself without even her but I was awful sick and 'he' was away; the doctor I didn't send for, the roads was bad." The little woman of fourteen was stolidly pleased that she had been helpful though she sensed enough of outside ways to watch the field-worker closely for any evidence of disapproval.

Whether or not intermarriage has increased the degeneracy of this stock it has kept it true to type through many generations. The pauper list of the town has as far back as record goes been almost unbelievable for the size of population; in surrounding towns a by-word for generations.

The town of Z——— has far more in common with the first described town of X———, though here again is a noticeable difference. Z———'s

first settlers were intelligent, probably in many instances something of the leader in their make-up. The colonization took place by reason of a church dissension. From a town and church some days journey away these pioneers who were willing to go through physical hardship and doubtless some economic loss for the sake of opinion of conviction, came to a valley (this time inland and in yet a third state of New England) to found homes where previously only the Indians had lived.

They were men and women of great religious zeal. They sought to convert their Indian neighbors, but were generally unsuccessful. They planted churches, one at first which today through sub-divisions of the original town has become at least a dozen while the main village of their settlement shows four Protestant churches where once was one. Naturally in a town of this type there have been frequent instances of pretence and hypocrisy but in as many instances have come out of the descendants of this settlement men distinguished in theology, in foreign fields of religious effort, in pulpits graced by names that are nationally known for sincerity, integrity and personality. And from this line of settlers who avowed their interest religious rather than as in the case of X ——— that of family property, upbuilding of fortunes by holding of property within the name, has come a race of people who have kept almost entirely free from intermarriage.

There are doubtless many reasons for this. While the community has through some two hundred to three hundred years been considerably isolated it has still been reasonably "well-known." It was once offered the county seat but its "fathers" sat in council and decided not to let wordliness and sin creep in. It was once offered the first choice of opportunity to a railroad center, but refused. The railroad was put through a small hamlet a dozen miles from Z———. Today what manufacturing industry, what money to be invested has all been moved to this progressive hamlet which is now one of New England's largest manufacturing cities, while Z——— is more dead industrially than fifty years after its settlement. The marked religious interests of Z———'s people were not of a freak type, but of one or two distinctly protestant denominations and their religion and ethics undoubtedly stood against intermarriage of blood relatives. Thus except for a few of the "black sheep" or a very few instances which any group of two to three thousand people through two hundred fifty years can show, intermarriage has been practically unknown. It is, however, true that mating has depended much upon propinquity further limited by isolation of community, until though actual relation in marriage is rare, the town is an almost inextricable group of "by marriage" relatives. This

coupled with a large influx of undesirables soon after the Civil War and by a two hundred and fifty years continual exodus of the more progressive, and a vegetation right in Z——— of those too inert or inapt to make their way in the great west, has worked for a very evident decadence which is at many points actual degeneracy.

In summary it is doubtless true that X——— with its intelligence and thrift is showing more and more a tendency, in this day of breaking from tradition, to out marriage. It will mean in some instances eugenic salvation; in others where the mental taint has become very marked it will but serve to carry into other strains of Yankee blood the cacogenic factor resulting most often in X——— in insanity and suicide.

No doubt Y——— is hopeless. It will in time accomplish its own extermination yet the town is a menace to the country for it is true that annually a few of the "prettier" girls or the less feeble-minded boys do drift out into the surrounding towns and marry. Wherever they go their traits hold true and the menace is especially great in instances where a reasonably eugeni cNew England man sets aside his feeling about Y——— and marries a pretty Y——— girl. This girl practically always bears the man a large family of children and in few instances are they other than true descendants of Y———, feeble mentally, moron at the most.

Z's probable uneugenic future is as indicated not to come from intermarriage, but rather from the fact that into her valley will continue to drift the unambitious, the uneugenic, those who prefer to avoid law, order and effort in the world outside—while her better stock will as it has for nearly three centuries tended to do, go out a few at a time in the persons of the youth of the town for greater opportunity.

FORMAL INBREEDING IN HUMAN SOCIETY WITH SOUTH AMERICAN EXAMPLES

HERBERT J. SPINDEN

Peabody Museum of Harvard University

The simple biological family, that is, the group composed of mother, father, and children, is universal and psychologically important among all human beings—normally speaking—while regulations in marriage carrying us at least a step beyond the natural family, are constantly seen in the larger organizations of human society. A fundamental classification of the social structures developing out of the simple family may take the following form:

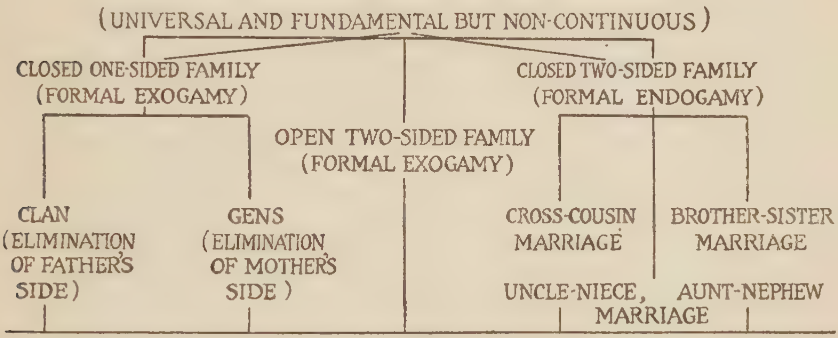


FIG. 1

NATURAL OR BIOLOGICAL FAMILY

Social classes, aristocracies, royal families, theocracies, etc., may develop out of any of these bases:

THE RACE (Common Blood)

|

THE STOCK (Common Language)

|

THE NATION (Common Culture)

THE LATERAL DEVELOPMENT OF THE FAMILY

PATTERN OF CROSS-COUSIN MARRIAGE ON THE FIELD OF CONSANGUINITY

DIAGRAM OF UNCLE-NIECE, AUNT-NEPHEW MARRIAGE

PATTERN OF CLAN SYSTEM ON FIELD OF CONSANGUINITY

Inheritance is on the mother's side, solid black. Father's side, shaded, is not represented among his own children, but instead among his sisters' children. The children of both the mother's brothers and the father's brothers belong to the clans of their mothers, C, C1; D, D1, etc. Finally, E, E1; F, F1, etc. record possible contacts with other clans established through marriage since the husbands of the maternal and paternal aunts must come from outside the clans of these women. Clan A may be substituted for D, D1; F and F1, and Clan B for C, C1; E and E1 reducing the exogamic groups to two.

The consequences of regulated inbreeding among human beings have a very real interest for students of eugenics. These students cannot expect to observe many cases of consecutive human inbreeding in the course of their own lives and they must either turn to the past or content themselves with applying to man certain principles of inheritance induced from observations on plants and animals with much shorter generations. If they turn to the past they often find insuperable difficulties in the matter of record. In certain favored localities, when genealogies are sufficiently detailed, inbreeding may take place but rarely.

I wish, therefore, to call attention to localities and peoples where there is reason to believe that a large percentage of the marriages have been of the endogamic or inbreeding type and where effective inbreeding may have been the rule over long stretches of time. It should be possible for properly qualified investigators to observe in some of these localities the results of close marriage in three or four generations of living individuals and to obtain information from older persons going back two or three generations into the past. I can present no data on the physical characters which might seem to have been determined or emphasized by such inbreeding, merely indicating fields where future eugenic research should prove profitable.

What I have here called the open two-sided family is perhaps the commonest form. As a rule the mother's side and the father's side are equally important, or, at least, both are held in consideration. Here we find a rigid prohibition, on moral grounds, of marriage within the closer degrees of consanguinity on both sides of the house. Partial inbreeding may result from consanguinous marriages which approach the prohibited degrees, especially in wealthy, aristocratic or ruling families. Among some southern European peoples marriages between cousins, uncle and niece, etc., are common, but never the rule. The normal human family is not a profitable field in which to study inbreeding.

The one-sided family (the term one-sided referring only to extensions beyond the simple family) occurs in both hemispheres and exhibits some very interesting convergencies. Anthropologists of the United States have come to a fair degree of accord as regards the words "clan" and "gens," the first referring to social groups in a tribe or village that follow

the mother-line and the second to similar groups that follow the father-line. Both are normally exogamic. There are often larger groups, made up of several clans or gens, and as regards these larger groups (phratries, if several in the tribe, or moieties, if only two) marriage is sometimes regularly inside the group and sometimes regularly outside. Theoretically neither the clan nor the gens is regarded as an extended one-sided family although often explained as such. The possibility is always held that a clan or gens may contain two or more families. The clan or gens is chiefly important because it serves as a basis of organization in religious or civil government. It ordinarily takes its name from, first, a tutelary being or totem; second, some object of nature which may or may not have a ceremonial relation to the group; and third, some geographical location which may, perhaps, be considered as the original home of the group. Clans and gens in different parts of the world are often superficially similar, while inwardly diverse. In relation to problems of breeding they are not nearly so important as often assumed to be.

Real inbreeding can only take place in a closed circuit which must take account of the inheritance from both parents. In the closed two-sided family marriage must ordinarily be held within a limited field of consanguinity. In practice, among so-called primitive people (who have just as long an ancestry as civilized people), the commonest form of close marriage is cross-cousin marriage. Of course any form of cousin marriage would be just as effective as this, for breeding purposes, but it happens that marriage between cousins who are the children of fathers' sisters or mothers' brothers is much more frequently dictated by custom than that between parallel cousins (children of mothers' sisters or fathers' brothers) or simply undifferentiated cousins.[1] With a difference of one generation, marriage is sometimes also formally demanded between nieces and their maternal uncles and between nephews and their paternal aunts. These two types of marriage prevailed among nearly all the important tribes and linguistic stocks of South America. Brother and sister marriage was formally

[1] Tylor in 1889 first called attention to the institution of cross-cousin marriage. He says: "In tabulating the nations of the world, I found a group of twenty-one peoples whose customs as to the marriage of first cousins seemed remarkable; it is that the children of two brothers may not marry, nor the children of two sisters, but the child of the brother may marry the child of the sister. It seems obvious that this 'cross-cousin marriage' as it may be called, must be the direct result of the simplest form of exogamy, where a population is divided into two classes or sections with the law that a man who belongs to Class A can only take a wife of Class B." (On a method of investigating the development of institutions; applied to laws of marriage and descent, Journ. Anth. Inst., XVIII, pp. 245–269.)

demanded among the ruling Inca of Peru. It probably does not survive today among any people except, perhaps, as an occasional anomaly. The levirate, where a man takes his dead brother's wives, and the somewhat analogous situation where sisters become the polygamous wives of the same man, or succeed each other in this service, are probably responsible for the development of the cross-cousin relationship as we shall see presently in a diagram. Both of these usages prevail over large parts of South America.

Now, I am aware that the cross-cousin relationship is recognized in the name when it has no present part in actual marriage. Among many American Indian tribes, with or without the clan or gens system, the children of mothers' sisters and fathers' brothers, that is the parallel cousins, are called by the same terms that signify brother and sister while the cross-cousins are designated by another term.

The classical comparison of Morgan between the relationship terms of the Iroquois of North America and the Tamil of southern India shows that the cross-cousin relationship complex was completely expressed in both. But in the case of the Iroquois, at least, there was no cross-cousin marriage. Simply, the term "father" covered a group including the real father and his brothers and the term "mother" covered a group including the real mothers and her sisters. The children of these various persons (and of outside persons joined to them in marriage) regarded each other as brothers and sisters. On the other hand, the sisters of the father were aunts, the brothers of the mother, uncles, and their children were grouped together as the only cousins.

Marriage among the Iroquois was exogamic as regards the social groups known as clans, and the membership in a clan was inherited through the mother. The real consanguinity system and the conventional clan system did not coincide. The group of persons that an individual could call his brothers and sisters was divided among several clans. The real brothers and sisters, plus the so-called brothers and sisters who were children of the mother's sisters, belonged to the mother's clan. The so-called brothers and sisters who were children of the father's brothers belonged to the various clans of their own mothers who had married these men. Similarly the cross-cousins, although grouped under one name, represented different clans. The children of the maternal uncles belonged to the various clans of the wives of these men, while the children of the paternal aunts belonged to the clan of the real father and his brothers, inherited from their common mother.

The explanation might be carried farther but enough has been said to show that clan-grouping and essential relationship grouping did not coin-

cide among the Iroquois. Nor do they coincide among other tribes having the clan or gens system. It is not enough to say of any tribe that marriage is exogamic as regards the clan or gens. Marriage is also controlled by consanguinity at one and the same time that it is controlled by the clan or gentile organization. The Iroquois could not marry those members of the brother-sister group who were outside their own clan. It is doubtful if they could marry their father's brothers and sisters—that is, their paternal aunts and uncles—although these persons were also outside of their own clan. Whether or not they could marry the cross-cousins, who were all outside their clan I am not able to say but among some tribes with clan or gentile organization the marriage of cousins is forbidden, or frowned upon.

The statement so often made that the clan or gens is an effective device to prevent inbreeding is utterly fallacious. It does of course prevent the marriage of certain relatives but it does not, by itself, prevent union of the same blood. It would be theoretically possible to have in a full-blown exogamic clan or gentile system a very effective kind of inbreeding. This type of social organization neglects one half of the extended family, as has already been pointed out. In other words, the barriers against inbreeding affect only one half of the field of consanguinity. Inbreeding results when the same blood is turned back continuously into the stream of descent through marriage within the real family. The clan or gentile system is a social superstructure that can be entirely neglected by students interested in inbreeding the races and strains of the human species.

If inbreeding is possible in types of human society which have apparently raised up barriers against it, and yet does not occur in the normal human family or at least does not occur with sufficient regularity to have a determinable eugenic effect, what does constitute good evidence of actual inbreeding? Let us examine a typical field of consanguinity covering two generations, giving all the type individuals. The same blood (this term must be taken to mean the complex of physically heritable characters) is present in all these type individuals possibly weakened in the collateral lines by the unrecorded second parents of the cousins.

The relationships given here are identical with those in the diagrams that follow.

Since any table of consanguinity must be made formal for comparisons it is understood that the three children of the mother and father (namely, Ego and this brother and sister), here shown on the top of the diagram, are reversible to the bottom of the diagram to complete the father line. It is assumed here that each parent has two brothers and two sisters and that each of these has two offspring, one male and one female. The husbands and wives of the collateral aunts and uncles do not appear in the diagram.

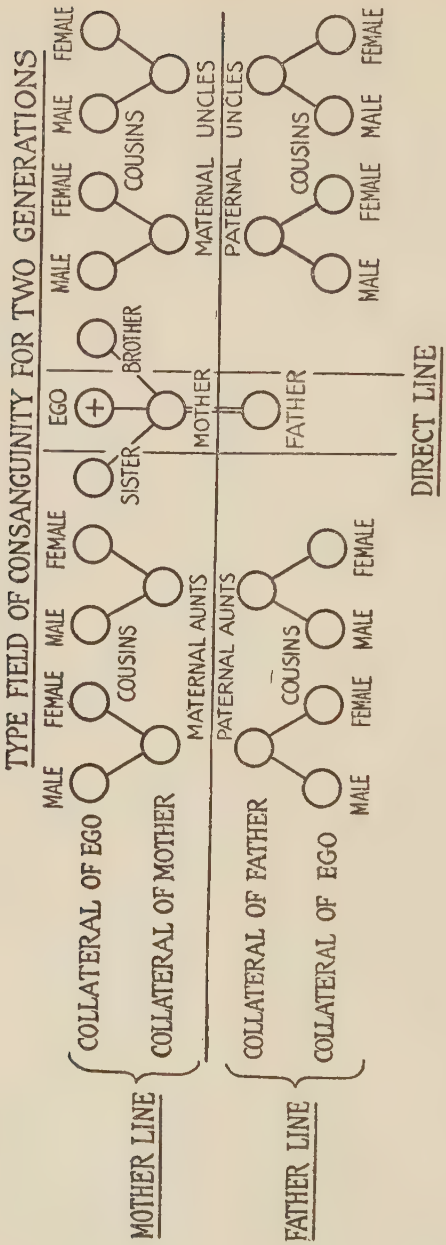

TYPE FIELD OF CONSANGUINITY FOR TWO GENERATIONS
MOTHER LINE
COLLATERAL OF EGO
COLLATERAL OF MOTHER
FATHER LINE
COLLATERAL OF FATHER
COLLATERAL OF EGO
MALE
FEMALE
MALE
FEMALE
COUSINS
MATERNAL AUNTS
PATERNAL AUNTS
COUSINS
MALE
FEMALE
MALE
FEMALE
SISTER
EGO
BROTHER
MOTHER
FATHER
DIRECT LINE
MALE
FEMALE
MALE
FEMALE
COUSINS
MATERNAL UNCLES
PATERNAL UNCLES
COUSINS
MALE
FEMALE
MALE
FEMALE

Fig. 2

Now if we superimpose upon this field of consanguinity the relationships established by the levirate, whereby the husband's brothers may succeed to his marital rights and the reciprocal system for which the term sororate has been suggested, whereby the sisters of the wife may assume her duties either by polygamous marriage or by succession we have the following aspect of the field of consanguinity:

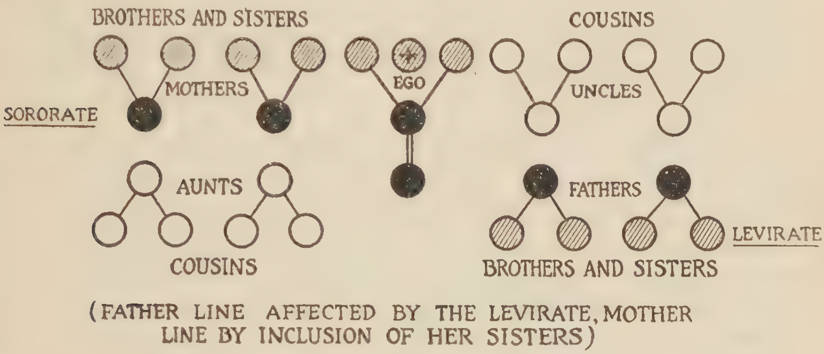


FIG. 3

Most convergences in human culture are brought about through some mechanistic constant. Given the natural family and the coöperative instinct, the assumption of the duties of a deceased husband by his brothers, and of a deceased wife by her sisters, is one of the few methods by which continuity of the group can be accomplished. It appears to me that the wide but broken distribution of the cross-cousin relationship complex is explained by the formal, or mechanistic, answer to this common problem of continuing the family organization contained in the above diagram.

The cross-cousin relationship is found among many tribes where cross-cousin marriage does not prevail, as has already been stated. It need not be assumed that cross-cousin marriage ever existed among such tribes, since the primary obligations of parental protection are sufficient to account for the form of organization. Farrand found the cross-cousin relationship perfectly developed among the Alsea of Oregon although the prevailing type of marriage was outside the tribe. But given the fundamental arrangement, then cross-cousin, uncle-niece, and aunt-nephew marriage might easily develop.

Any male of the brother-sister group, solid black, can marry any female of the cousin group, shaded, either laterally or across the field, and vice versa.

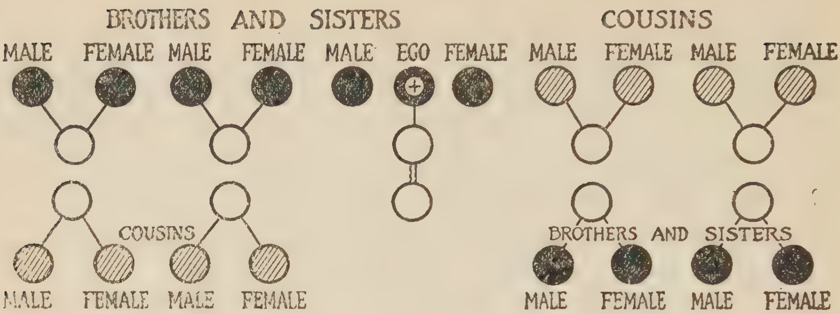


Fig. 4

The uncle-niece, aunt-nephew marriage presents an offset in the generation, so to speak. It doubtless occurs in combination with cross-cousin marriage rather than as a complete substitute for it. With this type of marriage the board is not cleared in two generations. Indeed it seems impossible that a marriage system could continue as a going concern where young men marry old women and old men young women unless each should mate once in youth and again in middle or old age. The diagram of uncle-niece and aunt-nephew marriage follows:

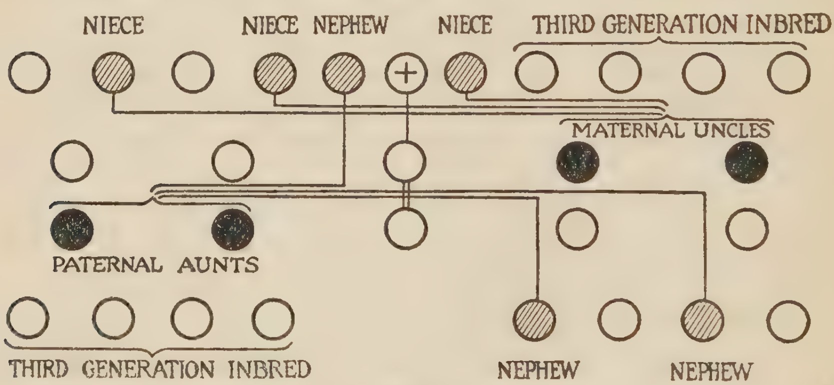


Fig. 5

It will be observed that all the members of the extended brother and sister groups of the previous tables do not analyze into nieces of the father's sisters and nephews of the mother's brothers. And the offspring of these marriages of different generations (in the position of the earlier cross-cousins) properly belongs to a third generation. It would seem that the cross-cousin marriage was a more perfectly operating system than uncle-niece or aunt-nephew marriage, but the two could probably be used in conjunction and the evidence shows that they were so used in some South American tribes.

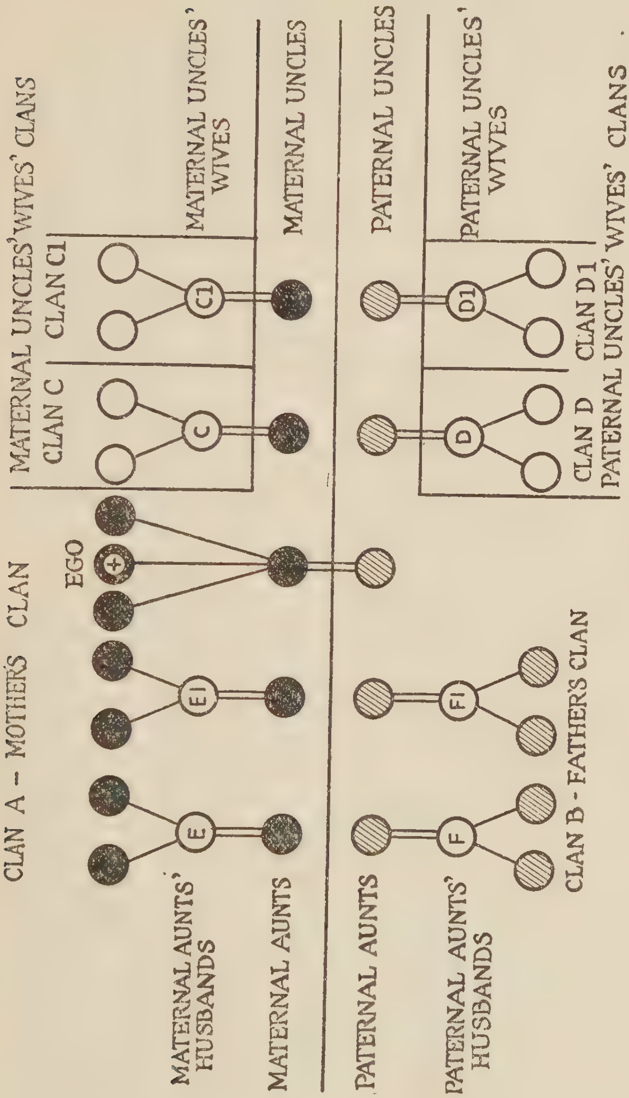

CLAN A – MOTHER'S CLAN
EGO
MATERNAL UNCLES' WIVES' CLANS
CLAN C
CLAN C1
MATERNAL AUNTS' HUSBANDS
MATERNAL AUNTS
MATERNAL UNCLES' WIVES
MATERNAL UNCLES
PATERNAL AUNTS
PATERNAL UNCLES
PATERNAL AUNTS' HUSBANDS
PATERNAL UNCLES' WIVES
CLAN B - FATHER'S CLAN
CLAN D
CLAN D1
PATERNAL UNCLES' WIVES' CLANS
E
E1
C
C1
F
F1
D
D1

Fig. 6

Let us now look at the same field of consanguinity when a formal clan system has been laid down upon it. Here we find it necessary to take account of affinity as well as of consanguinity since the clan inheritance follows the female who must always be of a different clan than the male with whom she mates. We have already seen, however, that a close type of inbreeding may take place in spite of clan and gentile restrictions.

If we had to depend entirely upon the direct statements in ethnological studies concerning close marriages in South America we would not consider our position strong. There are some clear references but they do not begin to cover the field. Thus Gilij speaking of the Orinocan Indians says:

> . . . . Many among the Tamanchi, select for wives their nieces, daughters of sisters. The maternal uncle is there called by the same name as otherwise is given to the father-in-law.[2] . . . . But there are no cases in which a young girl takes for a husband her paternal uncle. And after much consideration I have found that this is because they have the habit of calling him father.

Jean de Lery writes of the Indians of Brazil in the sixteenth century:

> Touching the marriage of our Americans, they observe only these three degrees of consanguinity; namely no one takes his mother, his sister or his daughter to wife, but as to the uncle he takes his niece and furthermore in all the other degrees of relationship no regard is paid.

The fact of uncle-niece and aunt-nephew marriage caught the attention because of the wide differences in age but it was not often grasped that the uncles were mother's brothers and the aunts were father's sisters. The mating of cousins is also noted by various early writers particularly among Carib and Arawak tribes. Thus Barrere, referring to the Galibes and other Carib tribes of French Guiana says: "Ordinarily the Indians do not make misalliances. Always they espouse their relations, even to the second degree of consanguinity. The youths regard their blood cousins as belonging to them by a certain right of birth. So they often marry them, even when they are only two or three years old. In the mean time another woman is taken who is sent away when the young cousin has grown sufficiently to enter into relations with her husband."

Priests are frequently outraged at the close marriages and assert that nothing except the first degree of consanguinity was sacred. On the other hand Roth tells us that the Arawak sometimes accused the Spaniards of incest. This was when they married parallel cousins instead of cross-cousins. Recently Señor Lefone Quevedo described the close-marriage

[2] This statement indicates that cross-cousin marriage also obtained: only in this way can the maternal uncle become the father-in-law.

customs of the southern Guarani. The present writer read a paper on the social organization of the Mosquito Indians showing that sexual hospitality is still the rule between unmarried cross-cousins and that normal marriage is within this relationship.

There is a kind of evidence which is abundant, and I believe conclusive, namely linguistic information. The Catholic Church forbids certain consanguinous marriages and permits others only after the payment of a fee for dispensation. As a result of this regulation we find a list of relationship terms in nearly every grammar and catechism written in South and Central American languages as well as in the occasional dictionaries. At first glance it might not seem that practically conclusive evidence of inbreeding customs could come from such sources.

But think of the coincident relationship terms when real relatives acquire a second title through marriage! With cross-cousins mating the following relationships coincide.

1. Cousin = husband = wife
2. Cousin = brother-in-law = sister-in-law
3. Maternal uncle = father-in-law
4. Paternal aunt = mother-in-law
5. Nephew = son-in-law
6. Niece = daughter-in-law

When, therefore, you find the same word having a double meaning which could only come about through cross-cousin marriage it is a pretty safe guess that this form of marriage existed. Just as an example: we know little enough about the Mosetenes Indians of Bolivia but in a short word list we find that *vi* means either brother-in-law or first cousin male, while *fom* means either sister-in-law or first cousin female. Such a coincidence of terms could only be effected through cross-cousin marriages. I have not space to present the linguistic data which are rather voluminous, but I may say that among nearly all Arawak, Carib, Tupi, Guarani, and Chibcha tribes as well as a number of smaller South American tribes the linguistic evidence of this double meaning of relationship terms in consanguinity and in affinity is mute testimony of a custom of inbreeding among these Indians.

Clan-like structures (except that they are probably endogamic family groups instead of exogamic groups) are sometimes found, as among the Bri bri of Costa Rica, the Goajiro of Colombia and Venezuela, the Araucano of Chile and possibly the Inca of Peru. Let us examine briefly the affairs among the last mentioned people. In the preamble of Incan history the four Children of the Son, with their wives, lead ten ayllu, or lineages, out of Tampu Focco, and, after a peregrination in which three of leaders were

killed or turned into stone idols, the ten ayllu settled at Cuzeo. The ayllu, in origin at least, was probably expanded endogamic families. According to Markham the marriage of brothers and sisters was a late development of the Inca royal house. This custom is also reported for the Nachez tribe of the lower Mississippi where the rulers, as in Peru, were regarded as children of the Sun and therefore divine. It is possible that brother and sister-marriage was made necessary by there being no other person of equal rank for each to marry. But surely such a custom would be more likely to grow out of endogamic practices such as cross-cousin marriage, than out of exogamic clans or gentes. Señor Lefone Quevedo in a letter to me containing valuable notes on South American relationship terms considers that the Peruvians had clans—but he would doubtless agree that these clans were endogamic rather than exogamic and, by definition clans must be exogamic.

Among other tribes the social structure was by villages. Farabee notes among the Arawak tribes of the southern British Guiana region cross-cousin marriage, that is outside the village. Thus family A is distributed in two or more villages, the girl must marry out of her village but within her family.

In closing, I only wish to emphasize the fact that close marriage was the rule rather than the exception among many South American and some Central American tribes and that it is still maintained. Of course it is not to be expected that any type of marriage could be maintained in pure form: love laughs at locksmiths. But enough intermarriage might have taken place to intensify family types among these tribes. Through its eugenic significance somatological research in South America should take on a new impetus. Skeletal work might also be carried out with the new thought in mind. It would seem that South America was the most promising field in which to study the results of human inbreeding.

THE EFFECT ON THE GERM PLASM OF ISOLATION IN A MOUNTAIN SECTION

W. S. ANDERSON

University of Kentucky

INTRODUCTION

One of the bluegrass counties of Kentucky extends to the foothills of the mountain section of the state. There is a strip of territory in this county four or five miles wide and eight or ten miles long just at the foot of the hills. This strip of land is rolling and traversed by small streams. The streams attain considerable volume during rainy seasons and some of them cease to flow at all during the dry summer months.

While most of the county is a very fertile and prosperous farming section of Kentucky the plateau at the foothills is a sandy clay almost worthless for the purpose of cultivation. The bluegrass land of the county is eagerly sought by farmers at from $150 to $300 per acre while this plateau soil can be purchased at from $5 to $40 per acre.

There is no natural barrier of any kind between the two classes of soils. At a certain very irregular line the rich phosphatic limestone disappears to lower depths and a shale, or sandstone crops out. The character of the two soils is as dissimilar as the strata out of which they have been formed. The one will grow bluegrass, clover, corn, wheat, hemp, tobacco, etc; the other is cultivated almost exclusively in corn and the return per acre is only a fraction of what good land produces.

ORIGINAL SETTLERS

About ninety years ago I J. M. and wife settled on this plateau. No information can be procured concerning their ancestry. The wife, as far as records show, was of good physique but of less than average intellect. I J. M. is described by a grandson, III A.M., as a man of very high temper which he was unable to, or at least did not, control. He had chorea. There are no records to show when the involuntary movements began in his case, but at the time he is remembered by III A. M. he had difficulty in feeding himself, requiring both hands instead of one to carry food or liquid to his mouth.

All the children of this couple drifted away from the plateau except one son, II E. M. The descendants through his sons and daughters who left this section of the state have been traced but no cases of chorea have been found among them; nor are they noted for any antisocial traits. We are only concerned with the descendants of the son who remained at the place of his birth.

The son, II E. M., who remained at home was affected with chorea in his old age much as his father had been. He was devoid of ambition and unable to obtain by his labor more than a bare living for himself and family. He was content to live in a log cabin, cultivate a few acres of unproductive land in corn and hunt and fish for his meat.

About the same time that I J. M. came to the plateau I A. W. took possession of another part of it. I A. W. and wife were quiet, unambitious, and mentally deficient, perhaps they should be classed as high grade morons. They were strong of body and able to do a great amount of physical labor. They did not work, however, except under the spur of necessity.

For a home they built a log house, covered with clapboards held in place by poles. The chinks between the logs of the house were partly filled with clay mortar. All furniture was made out of rough timber. If there was food for one day little thought was given to the needs of other days. Each spring a small plot of the unproductive soil was planted in corn.

To I A. W. and wife were born a large number of children, some ten or twelve living to maturity. The children, having high grade feeble-minded parents were all of the moron type, none of them showing more industry, ambition or intelligence than their parents.

A daughter, II B. W., of I A. W. married II E. M. the choreic son of I J. M.

In this marriage there is the union of two streams of germ plasm both of which are characterized by feeble-mindedness, the family of the husband carrying the taint of chorea as well as the moron tendency.

THE DESCENDANTS

To II E. M. and II B. W. were born four sons and three daughters. The descendants of the sons and daughters of II E. M. and II B. W. now constitute the entire population of the plateau and consist of 150 families numbering 900 people. The present population is as deeply inbred as a population can be not to allow brother and sister marriages. Cousin marriages and double first cousin marriages are common. Some blood

outside the two original families at first had to be introduced but now there are few or no marriages that do not trace on one or both sides to the one or the other foundation family and frequently to both.

MAKING PURE THE GERM PLASM

Had a breeder of domestic animals set out to produce an extensive herd of cattle all of which would breed true for two features, one a dominant and the other a recessive, he would have adopted by selection the exact method in making his matings which these people used in their marriages. The breeder would have striven to get his germ plasm pure for both traits. That is what has happened to the human germ plasm which has produced the plateau people. Feeble-mindedness is recessive. The original families both were pure for the traits and their children were pure. It has so happened that no out crosses have been made with normals, but always with subnormals and this has kept the stream pure. So far, then, as a deficient mental makeup is concerned the stream is pure and the fourth and now the fifth generation is breeding true.

The other trait, Huntington's chorea, is dominant and originally was in but one of the foundation families. By continual intermarriages of close relatives it has now become so near universal that some members of every family are victims and in many families all members suffer from some form of it. The cattle breeder to have introduced a dominant trait would have in his wisdom made the same close matings which the isolation and ignorance of these people have caused them to make.

THE EXTENT OF THE TRAITS

The writer can think of no hereditary human trait that is less desirable than chorea or one that in marriage should be more carefully avoided; yet here is a community that has fostered the "serpent" until every family is cursed by it. The germ plasm, by ignorant, consanguineous marriages, is rapidly becoming pure for chorea as it is for feeble-mindedness.

From the original progenitor, I J. M., there are now hundreds who carry and can transmit the trait; in fact, are transmitting it.

The two factors which have been most influential in tainting the stream of germ plasm are the low mentality of the population and the segregation of the people.

Were the people of normal intellectual endowment their knowledge would prevent the young people from marrying into the tainted families. Were they stronger mentally they would not remain in the community

which offers no opportunity for any of the comforts or pleasures of life. They would go where homes, and schools, and churches, and soils offer some commensurate return for energy expended. No natural barrier separates them from a most prosperous territory. The reason they stay on the poor soil is their lack of ambition, their absence of initiative and their willingness to congregate together.

It causes no very great concern to find one or two choreics in a community, but it is alarming that every home in a given territory has its victims. In fact it becomes a nuisance to the county and even to the State.

Owing to the primitive conditions under which the people live few of them have been sent away from home for care and treatment. Cases of extreme violence are kept at home by the neighbors coming in to aid in restraining them, which is done by physical force. A lack of refinement, and ignorance of the equipment and care given patients in modern asylums cause them to keep in their homes choreic patients who have reached the irresponsible mental stage in addition to their lack of muscular control.

BIOTYPES OF CHOREA

Davenport and Muncey[1] showed that Huntington's chorea has many species or biotypes. The chorea of the plateau manifests itself in many different ways in the different families. The age of onset varies. In some families the onset is after the age of menopause, while in others it is near the age of physical maturity and in still other families it manifests itself before the age of twelve. A few cases, as a seeming result of double cousin marriages, are recorded in which the infants were afflicted from birth.

One type manifests itself in very violent muscular movements especially if the patients are young. The name given to the disorder by the community is the "jerks." Strong men are required to hold children ten and twelve years of age in bed, when the attacks are at their most violent stage. In this severe type mental irresponsibility continues as long as the muscular contraction and improves as the treatment relieves the involuntary movements.

Another type is represented by V. Y. M., a young married woman. There was little involuntary movement in her case; but temporarily there was manic-depressive insanity. Her family would not consent to send her to the asylum and she constantly tried to commit suicide by drowning although there was no water nearby save a small stock pool. She would throw herself into this if left free for a few minutes.

[1] 1916 Bulletin No. 17, Eugenics Record Office.

One of the alarming types makes itself manifest at an early age, especially if there be any unusual stress. A representative example of this is the case of V. M. M., fourteen years of age. In June, 1921, she married a cousin sixteen years old. Immediately after assuming the marriage relation chorea developed in such a severe form that she lost all control of her limbs and voice. Separation from the husband and treatment are gradually restoring her health; but restoration is doubtless temporary as the universal rule for this type which appears so early is to recur again and again.

Perhaps, the most common type of the chorea manifests itself in the uncontrollable tempers of the victims. They are not mere irritations but intense outbursts of anger that lead to deeds of violence and murder even if the object of the anger is of the same family. Before and after the storms of temper there are the tremors and twitchings of the muscles which the patients cannot control any more than they seem to be able to control their angry passions.

The original carrier of the choreic germ plasm, I J. M., was noted for his violent outbursts of temper. It seems that in going on from one generation to another this disposition has become intensified until it is difficult to give in words the hold which it has upon his descendants. Even those who have little or no physical manifestations of chorea are characterized by ungovernable tempers.

THE MORALS OF THE PEOPLE

In the territory described there is segregated a considerable population rapidly degenerating to a pure race of choreics and imbeciles. Already the community is noted for its lack of a wholesome moral sense. At one time the men were skilled woodmen. They had a steady income from the sale of railroad ties, mortised fence posts, and logs ready for the saw mill. Long since the timber has been exhausted. The present generation exists on as little work as possible.

They consider it legitimate to sell their vote and this is freely practiced by both men and women. The distillation and sale of white whiskey promises to be their main industry. The low moral sense is severely condemned by the adjoining communities but the condemnation is made because the reason is not fully understood. The writer believes it is as natural as the uniform physical appearance of blue eyes and light hair and certain facial features.

We wish to make it clear that the isolation of the plateau is due to the lack of ambition in these people. They live under the hard conditions because they want to. They know that they do not have ability and ambi-

tion to go to the Bluegrass country nearby and set up a home. They are poor and they are making no effort to be otherwise. They love their kind. The sex appetite is their ruling passion but they believe it should be controlled until marriage. The result is that they often marry just at the end of childhood, long before they are fit either physically or financially. In fact they seem not to consider money or property necessary for marriage. If there is the impulse the marriage takes place and two immature people start a family of their own although the only prospective income is the uncertain day wage of the boy. The size of the family is only limited by the inability of the wife to reproduce and ranges from six to fifteen children. The ignorance of the mothers and their lack of sanitary conveniences cause a very high infantile death rate.

The in-and-in marriages, due in part to the voluntary isolation and in part to the inability of the young people to find marriage partners outside their own relatives, have resulted in concentrating in their germ plasm the factors for chorea, ungovernable tempers, imbecility, indolence, and a general anti-social disposition.

DÉVELOPPEMENT COMPARÉ DES PRODUITS SUCCESSIFS D'UN MÊME COUPLE

ETIENNE RABAUD[1]

Paris, France

Suivant une croyance populaire fort répandue le premier né d'un couple serait moins bien doué sous divers rapports que ses frères et soeurs puinés. Cette croyance, comme toutes les autres, ne reposent évidemment que sur des faits mal observés ou sur des préjugés sans fondement; elle s'impose néanmoins à bien des esprits comme une vérité démontrée. Ceux-ci en tirent alors la conclusion que dans un pays où les naissances sont peu nombreuses les aînés constituent une grande partie de la population qui, de ce fait, se trouve composée d'individus plus ou moins tarés.

Divers événements, la guerre en particulier, sont pour cette croyance un véritable contrôle en donnant aux diverses qualités individuelles l'occasion de se manifester. Il n'est pas inutile cependant de procéder à un examen rigoureux. Des statistiques bien conduites sur la descendance d'un trés grand nombre de couples humains fourniraient un résultat décisif. Ces statistiques n'existent pas et semblent peu faciles à établir. C'est pourquoi j'ai pensé qu'en étudiant la descendance d'un certain nombre de couples, d'une espèce animale quelconque on obtiendrait des indications suffisantes. Je rapporte ici les résultats de mes recherches sur les souris, me réservant d'en donner ultérieurement un exposé détaillé.

En thèse générale, je puis affirmer que mes recherches ne confirment nullement la croyance populaire. J'ai organisé mes couples de façon à répondre autant que possible à toutes les conditions: parents jeunes, parents vieux, parents d'âges très différents, l'un jeune, l'autre vieux, parents consanguins, parents étrangers l'un à l'autre. Aucune des conditions établies n'a mis en valeur de différences appréciables; ni les unes ni les autres ne déterminent chez les individus de la première portée des qualités physiques inférieures à celles des individus des portées suivantes. Chaque portée était pesée à la naissance, puis régulièrement pendant quatre semaines consécutives et une dernière fois au bout dû troisième mois. Des pesées supplémentaires étaient faites quand le besoin s'enfaisait sentir.

[1] Présenté par M. Marin Molliard.

Dans un grand nombre de cas, les portées successives d'un même couple se comportent de la même manière et leur croissance suit une marche parallèle. Voici, à titre d'exemple, les poids moyens relatifs aux cinq portées d'un couple:

	1 ère portée		2 ème portée		3 ème portée		4 ème portée		5 ème portée	
	Petits	Grammes	Petits	Grammes	Petits	Grammes	Petits	Grammes	Petits	Grammes
1 ère pesée ...	10	1.25	10	1.45	5	1.25	4	1.56	5	1.05
2 ème pesée...	8	2.60	8	2.73	5	2.05	4	3.56	3	2.66
3 ème pesée...	8	3.87	7	3.71	5	3.95	4	4.57	3	4.08
4 ème pesée...	8	4.78	7	4.42	5	5.85	4	6.81	1	6.00
5 ème pesée...	8	7.85	7	6	5	9	4	11.12	1	8
6 ème pesée...	8	25	7	23	5	22	4	24	1	24

D'une portée à l'autre existent évidemment des différences; mais elles sont insignifiantes et le résultat final est en somme le même. On remarquera au surplus que le nombre des petits allaités n'influe pas sensiblement sur la croissance.

Il est évidemment des cas où les différences entre les portées sont plus accusées; elles sont alors tantôt en faveur de la première portée, tantôt en faveur de la seconde. Parfois, il arrive que, la deuxième portée se comportant mieux que la première, la troisième se comporte moins bien. Tel est le cas de mon couple 57 dont les produits de 1 ère et 2 ème portées pèsent respectivement 20.50 et 22.50 grammes au troisième mois, tandis que ceux de la troisième portée pèsent seulement 13 grammes au bout du même laps de temps.

Dans ce cas, comme dans d'autres semblables, je n'ai pas observé de maladie intercurrente. Mais, en dépit de toutes les précautions prises, l'expérimentateur n'est pas maître de toutes les variables ni toujours en état de les connaître. On ne peut pourtant attribuer des différences de l'ordre de celles que je signale qu'à des modifications peut-être passagères survenues dans l'état des parents.

D'une façon très générale, je retire de mes élevages l'opinion que la croissance des descendants d'un couple, *dans les conditions normales de nutrition*, dépend de la constitution de chacun des deux composants de ce couple. De simples variations quantitatives apparaissent qui tiennent aux oscillations habituelles des influences du milieu extérieur ou intra-utérin; ces variations n'influent pas sensiblement sur le résultat final. Le rôle de la constitution des parents est particulièrement marqué dans certains cas de croissance un peu anormale et où l'on voit les mêmes faits

se reproduire dans les portées successives. Ainsi, le couple 31 donne des produits à croissance extrêmement rapide:

	1 ÈRE PORTÉE		2 ÈME PORTÉE	
	Petits	Grammes	Petits	Grammes
1 ère pesée	1	2.4	3	1.83
2 ème pesée	1	6.20	3	5.66
3 ème pesée	1	8.25	3	9.25
4 ème pesée	1	11.75	3	13.25
5 ème pesée	1	18.00	3	15.21

En 5 semaines, ces souris atteignent un poids que le plus grand nombre des souris n'atteignent qu'en 8 ou 10 semaines.

La conclusion se dégage donc d'elle-même. Il ne s'agit pas d'examiner l'ordre de *primogéniture* des descendants d'un couple, mais l'état des composants de ce couple et les conditions d'élevage. Celles-ci pourront certainement modifier celui-là; mais la question est alors toute différente.

THE IDEAL FAMILY HISTORY

HOWARD J. BANKER

Eugenics Record Office, Cold Spring Harbor, New York

The preparation of a family history while possessing many of the elements of historical method differs so greatly from all other forms of historical writing that it would seem to be entitled to a special designation of its own. The term Genealogy is correctly used in too restricted a sense so that the authors of family histories are constantly constrained to use qualifying terms in the titles of their works. On the analogy of the term biography we would suggest ecography as an appropriate expression and sufficiently broad in its implications.

Family history is much more closely allied to biography in every way than it is to history. In fact it is essentially a series of related biographies bound together by a genealogical net with only an historical background. Since this genealogical net is inherent in the family and is predetermined by biological laws which we can not change it constitutes a framework or skeleton that gives fundamental form to the family history. It forces certain very positive restrictions upon the writer of the family history and unless he has made himself master of the genealogy he is almost sure to be thrown if he attempts to ride this Pegasus. As most family historians are untrained, inexperienced and unacquainted with the best models of ecographic writing we find our genealogical libraries filled with a mass of poorly organized and undigested material from which it is sometimes possible to pick out fragments of more or less value.

But it does not appear to us that even trained and experienced professionals have always clearly comprehended the true nature of a family history study so as to treat it in a form that will give it its greatest value. The chief difficulty arises from the vague and ill defined use of the term family. In the broadest sense a complete family history never has and never will be written. The task is impossible. The material is not available and if it were no life would be sufficiently long to compass the work, to say nothing of the historian becoming lost in the endless ramifications of the family network. The fundamental problem of the historian then is to set the limits or the scope of his treatment so that it will include a natural

and unified family group. This apparently simple and obvious fact is, however, rarely attained even in the most elaborate and expensive family histories. Nearly all are not only fragments but they are distorted and often sadly mutilated fragments.

Two considerations are apt to control in determining the scope of a family history study neither of which is of the highest importance. The first is to trace back to the earliest possible ancestor and the second is to restrict the work to those lines that afford the greatest mechanical facility for the research. In the prosecution of the first object much labor and sometimes heavy expense is involved including the final publication of scores of pages of reproductions of old documents whose only value is that they furnish more or less certain evidence that leads to the conclusion that Thomas Tracy, the emigrant, was in all probability the son of William Tracy. The mountain has labored and brought forth a mouse. From any point of view of what great value is it to know that the father of Thomas was called William? Do not misunderstand me. I am too much of a genealogist not to appreciate the satisfaction one may feel in putting his finger squarely on the name of an ancestor one generation farther back. The question is, in satisfying this instinct have we not sacrificed other facts of as great interest and perhaps of even greater value? It is very well known that historical writings often suffer from distorted perspectives and no form of historical writing is likely to suffer more seriously from such distortion than is the family history.

Having run to cover the remotest ancestor the historian commonly proceeds to review more or less completely the descendants of the common ancestor and the emphasis here is frequently on less. It is very common practice to restrict this part of the family history to the descendants by the male line, a purely mechanical distinction but serving to facilitate research by confining the labor to the tracing out of a single surname. Every Berlove is grist for my mill. It is to be admitted that this greatly reduces the labor and expense of research as well as the size of the published volume. However, if we be not blinded by a false genealogical pride, this question must persistently intrude itself: Is the discovery of the name of the father of Thomas Tracy and the publication of all the documentary evidence therefor of greater interest, value or importance than the recording of the historical narrative of all his descendants including the female as well as the male lines? If both could not be included in the family history have we not sacrificed the greater for the less? Is not such a family history not only a fragment but a mutilated fragment for the line of limitation cuts continually right through the most intimate and vital relationships?

Such works may perhaps be called family annals but they lack the essential elements of a family history. They have not only a distorted perspective but they are seriously lacking in the fundamental requirement of all historical writing, unity. Even those family histories which include all lines of descent both male and female are still universally lacking in a highly important element of unity. The consorts of the so called "blood line" are commonly introduced with scarcely a comment as to their origin. Whether we view the subject historically, socially or biologically it must be recognized that the consort is just as vital and plays just as significant a part in the family history as does the old stock parent. They twain become one flesh. Both are essential to the unity of the home. Moreover the later descendants for whom presumably the history is written are just as greatly interested in the one parent as in the other and will not get a right conception of the influences which molded their family history unless an account is given of the consort's connections. The old and wide spread conception of a family tree belongs to the thought of an obsolete age. In conformity with social as well as scientific ideas of the present the family group must be conceived as a more or less intricate network.

Therefore, to secure, fundamental unity, to give to the family history the widest range of interest, and to preserve those features in the family network which have the greatest intrinsic value the following plan of structure should be more or less closely adhered to. Select a pair of consorts which, after a preliminary survey, seem most suitable for the purpose as planned. This may be determined by their prominence but is likely to serve the purpose better if chosen because of their central location within the family net which it is intended the history shall cover. Trace out their ancestry and ancestral fraternities in all lines for at least three generations. Then take up the descendants in the usual way following the order of primogeniture. With each consort, however, include the ancestry and ancestral fraternities for at least three generations. The historian should not be satisfied with less than this if the material can be obtained. Whether he should extend his work farther he must be his own judge, the fundamental principle being always to work centrifugally from a selected center including so much of the families of consorts as to give to the whole work a family unity. By this method of treatment the living members of the family will have a much larger interest in the work as a whole, the family history will be more unified and brought into better perspective, the social and other relations of family contemporaries can be more clearly brought out and the distribution of hereditary characteristics will be more strikingly and correctly displayed.

In such an arrangement of the family history it is evident that we have a central family stock nearly or quite complete surrounded on all sides by those familial factors and influences which have most vitally affected it. We have intimated that in this boundary region the historian may extend his limits according to his own judgment. It must be recognized, however, that too great an extension of the history into this outer region will defeat its own ends. First, the work will soon become unwieldy as well as uninteresting. Second, there is likely to be a loss of perspective when the border of the design becomes larger than the central figure. Third, the unity of the plan fades out in the unending diffuseness. We may soon reach the point where the central conception is dissipated and we are no longer dealing with a family but with a race.

The above comments apply just as distinctly to overexpansion vertically as laterally. In the downward direction we are stopped by the impassable boundary of the generation of the unborn, but there is no definitely fixed limit to the ascending series and there are peculiar fascinations in this direction. A little consideration will show, however, that there are limits beyond which it is of no practical value to go. If any of us could trace out his ancestors for ten generations he would find that he had over a thousand and the next generation alone would add a thousand more. From our present understanding of the biological mechanism for the transmission of hereditary traits it seems practically impossible that one should have inherited from all of these last thousand ancestors. In other words, it is all but certain that many of these ancestors of only three to four hundred years ago are no more related to some of us, their so-called descendants, than if they had been Fiji Islanders. Moreover, as to their having any influence on our lives through the family life or by means of their ideas or the environment which they established at the family hearth, it seems clearly evident that it can be no greater at this distance than the influence which we receive from any of their immediate contemporaries to whom we can trace no genetic relationship. In fact, when we trace our ancestry back ten generations or more we find ourselves dealing with a population and not with specific ancestors. Eventually, I am the descendant of a race and not of a person. It does not seem, therefore, to be of any vital significance as a rule to extend a family history over a period of more than ten generations. If there is significance in a greater series it is a special case due to the operation of some selective agency and becomes of interest as do all exceptions.

Thus far we have considered only the principles determining the plan or framework of the ideal family history. The next step is to give the plan

a concrete form adapted to the particular family to be studied. This is the strictly genealogical part of the work, but is essential. It consists of an enumeration of the members of the family with reference to their mutual relationships, each individual being identified by his name, date of birth, marriage and death and his place in the pedigree. All such data are simply means of identification and have no other significance. The relationships can be expressed in some cases by a numerical sequence or a system of tabulation, but by far the most satisfactory method where the family network is large and more or less complex is the pedigree chart. One might as well attempt to study the intricacies of a military campaign without a map as to study a family history without a chart.

Having settled on the plan or framework of the family history, the next problem is to put flesh on these dry bones that they may live. For this purpose each individual as far as possible must be clothed with personality. We are any of us interested to know that John Howland or Martha Spencer was one of our ancestors but how much greater is our interest if we can have pictured the appearance of John or Martha, can know more distinctly how they conducted themselves and in what they had their interests. After all, these are the things we really wish to know and these are the things that have scientific as well as historical value and personal interest. In the matter, however, of trying to reproduce this living personality the average family historian is too persistently looking backward. He has too much of the instincts of the antiquarian. The remotest and least known ancestor usually receives the largest attention, while those members of the family with whom the historian is well acquainted or concerning whom information may be readily acquired are passed over with scarcely more than the mention of the name, because forsooth they have not an antique flavor. A family historian does the greatest service to his family when he writes fully of those matters of which he knows the most. With face turned forward he should gather and record the information which he alone is in a position to preserve that the generations to come may have accurate portraits of their kin who passed away before their time.

Occasionally a father or mother does this for the children and these accounts though brief and often limited in scope are usually the most valuable of family chronicles. Such family narratives also approach more or less crudely the centrifugal type of family history which this paper has endeavored to present. The narrator is commonly the center and passes entirely around the circle of his family connection, describing each one and telling of their interests, achievements, personal appearance and peculiarities; their interrelations and reactions to each other and to their en-

vironment. Now if we can conceive of a score or more of such *raconteurs* properly grouped and united by the bonds of a common family network we have the finished structure, the body of the ideal family history. But not yet is it a living body. The highest type of family history still awaits the genius to give it full expression,—the man with comprehensive understanding, with broad conceptions and with profound philosophical insight, who is able to grasp this family group as a living entity, can analyze its complex internal reactions, the interplay of heredity and personality and then project it as a vital element in its social and physical environment, as a potential factor in the historical development of the race. This is the goal toward which as genealogists and ecographers we should strive. This is the ideal which should more largely animate and inspire our genealogical and patriotic societies. Preserve the past with all diligence but remember that tomorrow, today will be yesterday.

THE CONIFICATION OF SOCIAL GROUPS: EVIDENCE FROM NEW ENGLAND FAMILIES

FREDERICK ADAMS WOODS

Massachusetts Institute of Technology

The word conification, which appears in the title of this paper, has, as far as I know, never been used before. The introduction of a new word into a language requires an explanation, if not an apology. If any apology is needed, my hope is that it will be accepted rather in the nature of an excuse, because no other word could be found that at all well expresses the process to be described. The word "coniformation" is probably somewhat clearer, and is to be found in the Century Dictionary, though not often used. It means the formation of a cone. But it does not well express a general process. Just as we might speak of the solidification of groups and that groups solidify, so it is necessary to say that social groups at times show conification or conify, i.e., tend to point upward, like a cone.

If all the persons of a social group come together closely, in a mental or spiritual way, as for instance in a time of religious revival, or during a period of war, the group may be said to solidify. If a different process is to be described and some people, figuratively speaking, climb on the shoulders of others, the individuals form what may well be represented by the word conification.

In the accompanying figures we see in profile (or cross section) first a cone of flattened proportions like a flat turnip (fig. 1). This graph represents a group in which the individuals are, in any attribute under discussion, very much alike. Each individual might be represented by a single particle or dot. A few are near the top of the pile, a few are near the bottom, while the vast majority find their places in the broad median zone which constitutes the greater part of the structure. This median zone is emphasized by the lighter band.

The next diagram (fig. 2) shows a change. Some have succeeded in getting themselves into a higher position and some have been forced into a position even lower than before in relation to the mass. The third figure represents the same process carried to a greater degree.

Such graphs may be used to illustrate various special aspects of group differentiation, such as wealth, natural intelligence, outward achievement,

physical strength, stature,—in fact, any trait that can be measured. These cones can also be used to illustrate certain unmeasurable or vaguely measurable social and national differences. For instance, if one country is considered more aristocratic than another, the fact can be represented graphically by two cones, one of which is more pointed at the top than the other. Here, of course, the exact forms can not be plotted, but the idea can be put

FIG. 1

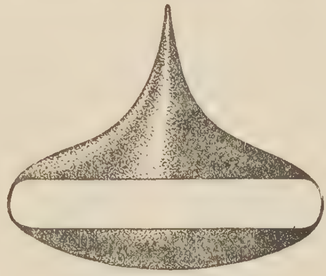


FIG. 2

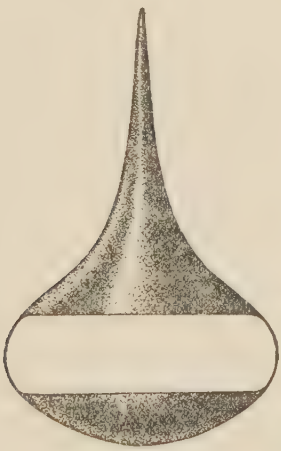


FIG. 3

into the form of a drawing,—a cross section of an object of three dimensions, —a solid object familiar to the eye and easily reproduced in the imagination. Conification is the transformation from the form of a flat turnip to one of the pointed variety. Nations can then be thought of, not as being composed of people who are all alike (which certainly they are not), but as composed of differentiated interacting particles. Thus, France and Germany before

the war might be represented by figure 2 and figure 3 respectively, or by one and two or by one and three. Figure 1 is the most democratic, figure 3 is the most aristocratic. The fact that there are such differences and that these need to be reckoned with in discussions relating to historical change is the point I wish to bring out.

There are always or nearly always forces at work acting towards conification or sharpening and raising the point of the social structure and there are always some forces acting in the opposite direction tending towards leveling the group. At times and in some countries these leveling forces have acted very suddenly, as during revolutions or conquests. The other or aristogenetic forces have scarcely been recognized though they are probably always active in civilized countries during normal periods of growth. Their activities are to be expected as corollaries of certain scientifically recognized facts. One of these facts is that, by and large, through the living world, like tends to mate with like, and this is true in a general way among civilized human beings. The children of the well-to-do and successful tend to marry within their own circle, while the poor, as a class, are forced to mate with the poor, and the middle classes on the average marry among themselves.

The second fact is that like tends to beget like. These two forces acting together lead towards diversification of the population as a whole. No one should doubt the reality of these forces. The only question is, do these inner forces, assortive mating combined with heredity, outweigh the environmental, leveling and democratic forces and produce a measurable result? Do nations and social groups, if left to themselves, actually conify or in other words become more aristocratic? There is evidence that they do.

First, there is evidence from the study of royal families. These families were originally formed through a process of selection, and a survival of the fittest in two important attributes, namely, success in war and government.

The early kings of the Anglo-Teutonic tribes were either elected for merit or made themselves kings by force of will and ability. Their children intermarried and their descendants for hundreds of years did produce on the average a very high proportion of men naturally gifted in the arts of war and government. There are about twenty persons of unquestioned genius, for the most part closely related, in a total population of less than one thousand.[1]

[1] Frederick Adams Woods, Heredity in Royalty, 1906, and The Influence of Monarchs, 1913.

Second, there is evidence from the British Dictionary of National Biography. It appears that, from the earliest times to the beginning of the nineteenth century, the contribution to eminent achievement made by the sons of craftsmen, artisans and unskilled laborers yielded 11.7 per cent of the total number of names. The same class born during the first quarter of the nineteenth century only produced 7.2 per cent of the total and I have found that the second supplement which contains names of persons born chiefly during the second quarter of the nineteenth century shows only 4.2 per cent born from the same working classes. Thus the great mass of the population appears to be more separated off from the upper classes than formerly, at least in this one particular respect, namely the power of producing men of exceptional talent.[2]

Third, a study of the history of representative New England families shows this conification actually taking place.

There is perhaps no small geographical territory in the world where local family records can be so easily and completely obtained as in Boston and vicinity. Most of the manuscripts have been printed and are to be found in the library of the New England Historic Genealogical Society. Wyman's history of Charlestown, Bond's Watertown, Paige's Cambridge, and Butler's Groton (the last supplemented by the numerous monographs of the late Dr. Samuel A. Green) carry local history almost to the final word. The records of births, baptisms, marriages, deaths, wills, deeds, town meetings, and military enlistments have been so thoroughly gone over for the earlier generations, that practically every person is known. The marriages are nearly all known, and the social status of the individuals and that of their parents are also known. Unfortunately we possess few facts concerning the inner traits and characteristics of most of these people, but we do know enough to be able to measure their comparative achievements; and their occupations and degrees of public service can almost always be determined. Private genealogies rarely contain anything bad about any one, but their writers are very eager to include all the good. Therefore, if there is nothing more to be found about a man than the dates of his birth, marriage, and death, we may be reasonably certain that, no matter how excellent he may have been in character, or even in natural ability, as far as his relation to the community was concerned he was not an influential man. The social order demands achievement, and towards merit without achievement its indifference is but natural. It is the relative achievements as well as the social positions of these people that can be studied with comprehensive results.

[2] See Alleyne Ireland, Democracy and the Human Equation, p. 139, for the application of this matter to the theory of democracy.

Also we may follow the intermarriages between the different social classes and estimate fairly well the class distribution of wealth.

As has been always recognized, the great majority of the early settlers in Massachusetts Bay belonged to the class, at that time alluded to as the yeomanry. There was a sprinkling, say 5 per cent, of gentry, and a very small and almost negligible number of vagrants or others now called "undesirables," but there were probably no breeds of degenerates such as were formed in certain hill-towns in later days. There were no tribes of "Jukes" or "Nams" at the start.

The gentry was made up in part by those who belonged to the recorded gentle families of England,—in other words, had the right to a coat of arms. There were surprisingly few such families and modern critical research has shown that the number probably does not exceed seventy-five for all New England. There were others who must be counted as belonging to the gentry, owing to their wealth or their high governmental offices or their membership in the then dominating theological class. College graduates and members of the learned professions may also be included in the class called gentry. Artisans and small shopkeepers may be classed with yeomen.

Between the gentry and ordinary yeomanry there existed certain individuals who, though comparatively uneducated, according to our present standards, were nevertheless real and practical leaders, and doubtless intelligent, enterprising, and courageous. They were the typical officers of the militia and pioneer founders of new towns on the frontier. These, if yeomen, I have called "officer yeomen," and we can often even speak of whole families as "officer yeoman," when a considerable number were closely related. The Massachusetts Society of Colonial Dames has listed in its Register a very large proportion of such persons, as well as those of greater prominence. These are considered as "eligible" ancestors for the election of their descendants in the Society.

Starting with this Register I have taken out the names of all families settled prior to 1692 who had three or more members now eligible as ancestors for Colonial Dames and at the same time lived in Boston or Charlestown, Watertown, Roxbury, Cambridge, Concord, Woburn, or Groton. This furnishes a list of seventy-one families or male-lines. Out of this seventy-one, forty (whose names are here given in the footnote[3]) were chosen,

[3] Families of the gentry and "officer yeomanry" in Boston and vicinity whose pedigrees have been studied and included in this research:

Adams,[2 3] *Appleton*,[2,3] Bigelow,[3] Boylston,[2] *Bradstreet*,[2] Breck,[2] Brooks,[3] *Bulkeley*, Chandler,[2] *Chauncy*,[2] Cheever, Converse, Coolidge,[3] *Dudley*, Farwell, French of Cambridge,

partly because of personal interest and knowledge that these families were today represented by descendants of more or less prominence, and partly because they happened to be connected with those taken at the start, so that the inclusion of one led to the inclusion of another, as the pedigree charts expanded, until a sufficiently great group of names had been obtained. This has now exceeded 3000 and it does not seem necessary to carry it further. There is no reason to suppose that the remaining thirty-one families whose names are also given in the second footnote,[4] and whose records were not included merely from lack of sufficient time, would in any way affect the present conclusions.

It has been the aim in this research to select by an objective method a characteristic leading class in America in the early days to compare with a similar class in the nineteenth and twentieth centuries. The great striking fact is that the upper portion of the body-social, as represented by families of the gentry, is more separated from the mass today than it was in colonial times. At least in two very important matters it is so separated. The first is wealth and the second is intermarriage. These both mean conification.

As regards the distribution of wealth among the four classes considered, we know that the total proportion of paupers and dependents was very small in the early days. The average yeoman possessed, as shown by inventories of wills, about £100 to £300. If a man had more than £300 personal property he might, with propriety, wear lace. At least there was at one time a law passed forbidding the use of lace to persons not possessing £300 personal property. Well-to-do yeomen, officer-yeomen, and gentlemen in the then technical sense of the word often possessed from £500 to several thousand pounds. Rev. Peter Bulkeley, the founder of Concord, a member of a very old English family and one of the most wealthy men in the colony, brought with him from England £6000. Robert Kayne of

etc., Frothingham,[3] Hancock,[2] Hunnewell,[3] Johnson of Woburn, Lawrence of Groton,[3] Learned, Lynde, *Mather*, *Minot*,[2,3] *Oliver*,[2] *Phillips*,[2,3] Prescott,[2] *Quincy*,[2,3] *Russell*,[2] Ruggles, *Saltonstall*,[2,3] Sparhawk,[2] Stearns of Watertown, Symmes, Tarbell, Willard, *Winthrop*,[2] Woods of Groton, Wyman. The thirteen names selected as showing special prominence in the first century are in italics. Those marked[2] were selected for the period 1721–1820. Those marked[3] for the period 1820–1921. The middle period, 1721–1820, has not been finished. A rough estimate indicates that the change from the earlier century was not great, until about the beginning of the nineteenth century.

[4] The following families have not as yet been studied: Allen, Barrett, Bowers, Clapp, Clark, Cotton, Craft, Danforth, Davenport, Denison, Eliot, Fiske, Foster, Gookin, Hutchinson, Leverett, Mason of Watertown, Pynchon, Sargeant, Savage, Sawtell, Sewall, Shrimpton, Sprague, Stoddard, Stone, Tyng, Thurston, Weld, Wheelwright, Whittingham.

Boston, one of the richest men in the first generation of settlers, left an estate in 1656 valued at £2569. Captain Thomas Brattle died in 1683, leaving an estate of £7827, which according to Savage was, "probably the largest in New England." Thus we see that the richest men were not more than fifty times as rich as the average. By the middle of the eighteenth century the differences had become somewhat greater. In Dwight's Travels it is said that Col. Elisha Doane of Wellfleet and Boston, and Thomas Boylston, of Boston, were estimated by their fellow citizens the two richest men in the province of Massachusetts Bay. Doane's fortune was estimated at £100,000. This was perhaps 300 times that of the average citizen.

In a gossipy little book called the "Rich Men of Massachusetts," published in 1851, we find a number of persons estimated as worth a million dollars or more. The richest man is placed at three millions. This must be more than 600 times the average. The differences increase as we approach the present day, during which time many persons in New England have left estates valued at twenty millions or more, or several thousand times the average. If we consider the United States as a whole, the very richest men today, those who are worth $100,000,000 or more, are certainly as much as 10,000 times to 100,000 times as rich as the average. There can be no question that, as far as the distribution of wealth is concerned, there has been in America a process of conification. The average has risen somewhat, but the point of the cone has risen faster than the mass. If the mass be represented in the graph, as six inches high, the top of the drawing would have to be carried up at least 5000 feet in the air.

Now let us examine the question of social differentiation as shown by the intermarriages of the different classes. We are apt to think of the colonists of the seventeenth and eighteenth centuries as very particular about their social rank. In outward forms they may have been. They were very particular about precedence in seating in church and somewhat so in arranging names in college catalogues, though not rigidly so, as a study of the early Harvard class lists will show. But when it comes to the matter of marriage and intermarriage between the three different social classes, we find a surprising lack of just this class distinction. There is certainly no better test than intermarriage between classes to show whether different castes mingle freely in a social way. At least this is the biological or eugenic test par excellence, as it is the one which determines the heredity of the next generation.

It is true that even in the earliest period there were certain families that may be spoken of as belonging to the gentry. These naturally intermarried

to a considerable extent, just as is the custom everywhere. Characteristic families of this description are represented by those of the governors, Dudley, Bradstreet, Winthrop, and Saltonstall, the wealthy Russell family of Charlestown, and the ancient pedigreed and theocratic families of Bulkeley and Chauncy. There are included in this study thirteen such preëminent families (prior to 1721) out of the total of forty. But in scarcely one of these is there not an instance of intermarriage with yeomanry, and usually many such examples can be counted.

At this point I wish to express my indebtedness to the well-known genealogist, Mr. J. Gardner Bartlett, who has gone over most of the data concerning the early settlers and has assisted in classifying the persons into the three grades here considered. As Mr. Bartlett has written a large number of histories of New England families, containing thousands of names, and has also specialized in the English ancestry of the early settlers, he is peculiarly fitted to aid in this way. My own feeling is that no one else could have done this work better than he, and I have used Mr. Bartlett's classification rather than my own whenever there has been a question. Thus a point is gained towards objectivity and impartiality, always a desirable feature in any historiometric work. Other things equal, it is better to report on other people's measurements than on one's own, especially when personal theory enters into the matter.

In this case I did have the theory, outlined in a chapter published in 1913, in the "Influence of Monarchs," that social conification, must in civilized societies be a normal process, but this is the first local evidence obtained. Here we really see the forces of aristogenesis sprouting up against and through the forces of democracy, making themselves obvious and easily susceptible of statistical proof.

Out of the forty families (male-lines) studied, thirteen have been selected as undoubtedly belonging in the highest social position during the period prior to 1721. These are italicized in the footnote on page 316 already referred to.

A detailed analysis cannot be given here, but in a word, the result is that out of 204 cases of marriage, in this early period, 48 or 23.5 per cent were marriages of the children of the gentry with the children of yeomen or, in other words, cross-marriages between the upper and the lower of the three social grades here considered.

After finishing this bit of statistical inquiry, I found, on re-examining the "Memorial History of Boston" (a standard work in four volumes prepared by a group of scholars and specialists), that a list of forty families socially prominent in the seventeenth century had been prepared by W. H. Whitmore, author of the chapter dealing with the social life in Boston.

Here were a good many names not included in my research. These were families strictly associated with Boston, and not with the outlying towns. Fearing that my own list did not represent a true selection of the most important names, and so might falsely overestimate the amount of cross-marriage of gentry with yeomanry, I looked up the records of the first seventeen of these families and found that the first hundred marriages yielded again approximately 23 per cent of cross-marriages between the upper and the lower of the same three grades.

Let us now contrast these conditions with those during the last hundred years. Twelve families are again selected *from the same forty* whose pedigrees have been traced. These are the families who appear to have had during the last century (1821–1921), the greatest amount of social and financial prominence. They are marked 3 in the first footnote. A few others might equally well have been selected from my list of forty pedigrees, but they have been omitted because their members have to a great extent moved away from Massachusetts or have now only a few representatives in the male-lines. Of course dozens of families, if selected for present day prominence, might be added, but that would mean another research.

The result of looking up the records of marriage and parentage in the twelve families that happen to be included shows within the last century that out of 152 marriages at least 143 or over 94 per cent, are certainly within their own class. There are not more than two instances of known marriages distinctly outside the class to which these people belong. The parentages of a few of the persons who happen to fall within this group are very difficult to trace in any printed records; probably most of them came from a class between the two extremes, such as, for the colonial period, we have called officer yeomen. But it is not necessary to know the ancestry of these few persons. Even if they are considered as Y (or similar to yeomanry of early period), the percentage of cross-marriages gentry with yeomanry has been reduced from 23 to less than 6. If we look at it another way out of 204 marriages from families of the gentry in the earliest period, 119 or only 58.3 per cent were within their own grade. During the third period, subsequent to 1820, at least 94 per cent have been strictly within the same class. The tendency towards casts marriages has increased markedly, and has increased recently.

These facts taken in conjunction with the increasingly uneven distribution of wealth prove that social conification does take place. It is probably inevitable whenever a population, at first composed of comparatively similar persons, lives in a territory where inheritable wealth can be acquired. It is probably working all the time in all civilized countries, though it may,

since it requires several generations to show its results, be masked superficially or buried under the wreckage of revolutionary débâcle.

Recently in Germany, Austria, and Russia, for instance, there have been gigantic examples of the breaking down of cones. Probably many social cones tend to break, some for one reason, some for another, as they become overconified, or too much pointed at the top. But they certainly tend to form, and it is merely to bring forth statistical and historical evidence of such formation that the present paper has been prepared.

The process of conification is hastened and intensified from the correlation that exists between social status and intellectual achievement. This correlation has been demonstrated in royalty, in nobility, in American families connected with persons in the Hall of Fame and in other material. The present research was not undertaken to prove the existence of such a correlation, since this had been known and recognized, but it is not without interest to see how many persons show high intellectual attainments in a group of families selected solely for wealth and social position since 1821.

This group of less than two hundred persons yields the following names at or above the standard of inclusion of Who's Who in America: Charles Francis Adams born 1809. Charles Francis Adams born 1835, Henry Adams born 1838. Brooks Adams, Dr. Henry J. Bigelow, Phillips Brooks; Algernon, T. Jefferson, J. Randolph, Julian L. and Archibald C. Coolidge; Rev. Nathaniel, Rev. Octavius B., Rev. Paul and Louis A. Frothingham; Amos A. (born 1814) and Bishop William Lawrence, Dr. Charles S. Minot, Wendell Phillips.

When one considers that not one adult male in a thousand attains any such distinction and that here out of a group of less than two hundred men and women, one can easily count nineteen, one sees how undoubtedly positive this correlation is.

The conclusion appears unescapable that no matter how much we may contemplate environmental forces, making for equality and democracy, here the real result has been in the opposite direction, namely, class differentiation and conification, due presumably to the accumulating forces of assortive mating, heredity, and the possibilities of transmitted wealth.

GENTRY, FIRST PERIOD (PRIOR TO 1721)

Appleton

Gentry × Gentry

Capt. John b. 1622	m	dau. Rev. Jesse Glover
Col. Samuel b. 1625	m	dau. William Paine of Ipswich
" "	m	(2) dau. John Oliver of Newbury.

Sarah	m	Rev. Samuel Philips
Judith b. 1634	m	Samuel Rogers of Ipswich
Judith	m	Samuel Wolcott of Wethersfield
Samuel b. 1654	m	Elizabeth Whitingham
Oliver b. 1672	m	dau. Tobijah Perkins of Topsfield
		Gentry × Officer Yeoman
Major Isaac b. 1664	m	dau. Thomas Baker of Topsfield
		Gentry × Yeoman
Martha b. 1620	m	Richard Jacobs of Ipswich
John b. 1660	m	(2) Elizabeth Dutch of Ipswich
Joannah	m	Mathew Whipple

BRADSTREET

Gentry × Gentry

Hon. Simon b. 1663	m	(20, widow Ann Gardner)
" "	m	dau. Gov. Thomas Dudley
Dr. Samuel H. C. 1653*	m	Mercy Tyng
Dorothy	m	Rev. Seaborn Cotton
Sarah	m	Richard Hubbard, H. C. 1653
Rev. Simon	m	dau. Rev. John Woodridge
Dudley	m	Ann widow of Theodore Price
John 1653	m	dau. Rev. William Perkins
Mercy b. cir. 1667	m	Dr. James Oliver
Lucy	m	Hon. Jonathan Remington
Dudley b. 1678	m	Mary Wainwright
Simon b. 1682	m	dau. Rev. Joseph Capen
		Gentry × Officer Yeoman
Hannah	m	Andrew Wiggin of Exeter, N. H
Mercy	m	Maj. Nathaniel Wade
Rev. Simon	m	Mary Long dau. John of Charlestown
Sarah	m	(2) Maj. Samuel Ward

BULKELEY

Gentry × Gentry

Thomas b. 1617	m	dau. Rev. John Jones
Elizabeth	m	Rev. Joseph Emerson
"	m	(2) John Brown Esq.
Jane	m	Capt. Ephraim Flint
Capt. Joseph b. 1670	m	Mrs. Rebecca Minot
" "	m	(2) Silence Jeffrey
Rev. Gershom	m	dau. President Chauncy
Peter	m	Rebecca Talcott

* H. C. = Harvard College graduate.

Gentry × Officer Yeoman

Hon. Peter	m	dau. Lt. Joseph Wheeler
Rebecca	m	Jonathan Prescott Jr.
Dorothy	m	Lt. Thomas Treat
Edward	m	Dorothy Prescott dau. of Jonathan
Rev. John	m	Patience Prentice

Gentry × Yeoman

Rebecca b. cir. 1695	m	Joseph Hubbard
Catherine b. cir. 1660	m	Richard Treat

Chauncey

Gentry × Gentry

Sarah	m	Gershom Bulkeley
Katherine	m	Rev. Daniel Brewer
Abigail	m	Dr. Hudson
Sarah	m	Rev. Samuel Whittelsey
Charles d. 1711	m	dau. Judge John Walley

Gentry × Officer Yeoman

Abigail	m	Edward Burroughs
Rev. Nathaniel	m	Sarah Judson

Gentry × Yeoman

Rev. Nathaniel b. 1639	m	Abigail Strong

Dudley

Gentry × Gentry

Gov. Thomas	m	Mrs. Catherine Hackburn
Rev. Samuel b. 1610	m	dau. Gov. John Winthrop
" "	m	(2) Mary Byley
Anne	m	Gov. Simon Bradstreet
Patience	m	Maj. Gen. Daniel Denison
Sarah	m	Maj. Benjamin Keaine
Mercy	m	Rev. John Woodbridge
Deborah	m	Jonathan Wade
Gov. Joseph	m	dau. Judge Tyng
Paul "merchant"	m	dau. Leverett
Thomas "sea captain"	m	Abigail Gilman
Judge Paul F.R.S.	m	Lucy Wainwright
Rebecca	m	Samuel Sewall
Mary	m	1675 Dr. Thomas Hardy
Hon. William b. 1686	m	dau. Judge Davenport
Catherine	m	Lt. Gov. Dummer
Mary	m	Francis Wainwright

Gentry × Officer Yeoman

Anne b. 1684	m	(2) Jeremiah Miller
Elizabeth	m	Hon. Kinsley Hall
Stephen	m	dau. Hon. John Gilman

Gentry × Yeoman

Anne	m	Edward Hilton
Sarah dau. Gov. Thomas	m	(2) Thomas Pacy
James b. 1663	m	Elizabeth Leavitt
Abigail dau. Rev. Samuel	m	Jonathan Watson
Dorothy	m	Moses Leavitt
Rebecca	m	Francis Lytard
Samuel	m	dau. Jonathan Thyng
Rev. Samuel	m	(3) Elizabeth
Beyley	m	dau. Moses Gilman

Mather

Gentry × Gentry

Timothy	m	dau. Maj. Gen. Humphrey Atherton
Rev. Eleazar	m	dau. Rev. John Warham
Rev. Increase	m	dau. Rev. John Cotton
" "	m	(2) widow Rev. John Cotton
Rev. Samuel b. 1650	m	dau. Gov. Robert Treat
Rev. Cotton F.R.S.	m	dau. Col. John Phillips
" "	m	(2) dau. Dr. John Clark
" "	m	(3) dau. Rev. Samuel Lee
Elizabeth	m	Josias Byles
Sarah	m	Rev. Nehemiah Walter
Abigail	m	(2) Rev. John White
Hannah	m	Peter Oliver
Jerusha	m	Peter Oliver
Abigail b. 1694	m	Daniel Willard
Atherton b. 1663	m	(1) Rebecca Stoghton

Gentry × Officer Yeoman

Joseph b. 1661	m	Sarah Clapp

Gentry × Yeoman

Richard b. 1653	m	Catherine Wise
Catherine	m	1651 Ebenezer Withington
Atherton b. 1663	m	(2) Mary Lamb
Samuel b. 1683	m	Deborah Champion
Capt. Timothy 1681	m	Sarah Noyes (?)
Lt. Joseph 1686	m	Phebe
Dr. Samuel H. C. 1698	m	dau. Samuel Grant

MINOT

Gentry × Gentry

James b. 1628	m	dau. Col. Stoughton
Capt. John b. 1626	m	dau. Nicholas Butler (or 0)
Elizabeth	m	Rev. John Danforth
Mehatabel	m	(2) Soloman Stoddard
Stephen b. 1688	m	(1) dau. Col. Francis Wainwright

Gentry × Officer Yeoman

James H. C. 1675	m	dau. Capt. Timothy Wheeler
Col. Stephen b. 1632	m	dau. Capt. Christopher Clark
Col. James b. 1694	m	dau. Col. John Lane
Stephen b. 1688	m	(2) dau. Capt. John Brown
Elizabeth	m	Capt. Daniel Adams
Stephen	m	Trucross Davenport

Gentry × Yeoman

Capt. John b. 1626	m	(2) Mary Biggs
Samuel b. 1635	m	Hannah Howard
John	m	dau. Edward Breck
Samuel	m	Hannah Jones
James b. 1659	m	Rebecca dau. John Jones
Mehetabel	m	Thomas Cooper (prob.)
Rebecca b. 1685	m	Joseph Barrett
Lydia	m	Benjamin Barrett
"	m	(2) Samuel Stone
Mary	m	Ebenezer Wheeler
Rev. Timothy	m	dau. Noah Brooks

OLIVER

Gentry × Gentry

Rev. John H. C. 1645	m	Elizabeth Newdigate
Peter	m	Sarah Newdigate
Nathaniel	m	dau. Thomas Brattle
James	m	dau. Samuel Bradstreet
Daniel	m	dau. Hon. Andrew Belchor
Sarah	m	Rev. Caleb Throwbridge
Oliver b. 1677	m	Sarah Perkins of Topsfield

Gentry × Officer Yeoman

Thomas	m	dau. Capt. Thomas Prentice
Abigail	m	Hon. Benjamin Prescott

Gentry × Yeoman

John	m	dau. John Sweet
Thomas	m	(2) Mary Wilson
Sarah	m	John Noyes
Elizabeth	m	Enoch Wiswall

PHILLIPS

Gentry × Gentry

Rev. George	m	dau. Richard Sargent
Rev. Samuel	m	Sarah Appleton
Samuel b. 1657	m	dau. Rev. John Emerson
Elizabeth	m	Rev. Edward Payson

Gentry × Officer Yeoman

Rev. Samuel	m	dau. Capt. John White
Sarah b. 1691	m	William White of Haverhill, N. Y.
Mary	m	Capt. Geo. Abbott
Ruth	m	Samuel White of Haverhill

Gentry × Yeoman

Elizabeth	m	Job Bishop of Ipswich
Zerobabel	m	Anne White
Jonathan	m	Sarah Holland
Theophilius	m	Mary Bennet
Abigail	m	James Barnard
Sarah	m	Stephen Mighill

QUINCY

Gentry × Gentry

Lt. Col. Edmund	m	(2) dau. Maj. Gen. Gookin
Daniel	m	dau. Rev. Thomas Shepard
Judith	m	Rev. John Rayner, Jr.
Elizabeth	m	Rev. D. Gookin
Mary	m	Rev. D. Baker
John	m	dau. Rev. John Norton
Edmund b. 1681	m	Dorothy dau. Rev. J. Flint
Joanna	m	David son Rev. Peter Hobart

Gentry × Officer Yeoman

Ruth	m	Capt. John Hunt of Weymouth
Judith	m	John Hull

Gentry × Yeoman

Experience	m	William Savil of Braintree

Russell

Gentry × Gentry

Hon. James b. 1640	m	Mabel Haynes
" " "	m	Mary Wolcott
Rev. Daniel	m	dau. Samuel Willis
Mehetabel	m	Rev. John Hubbard
"	m	(2) Rev. Samuel Woodbridge
Hon. Daniel	m	dau. Capt. Charles Chambers

Gentry × Officer Yeoman

Elizabeth	m	Capt. Nathaniel Graves
Mabel	m	David Jenner
Mary	m	Capt. John Miller

Gentry × Yeoman

Katherine	m	William Roswell
Maud	m	Daniel Lawrence

Saltonstall

Gentry × Gentry

Nathaniel H. C. 1659	m	dau. Rev. John Ward
Gov. Gurdon	m	dau. James Richards
Elizabeth	m	Rev. John Dennison
"	m	(2) Rev. Roland Cotton
Richard	m	dau. Capt. Simon Wainwright

Gentry × Officer Yoeman

Nathaniel H. C. 1695	m	widow of John Frizel

Winthrop

Gentry × Gentry

Elizabeth	m	Rev. Antipas Newman
"	m	(2) Zerubbebel Endicott
Lucy	m	Major Edward Palmes of New London
Margaret	m	John Corwin
Martha	m	Hon. Richard Wharton
Anne	m	Hon. John Richards
Waitstill	m	Mary d. Hon. William Browne
"	m	(2) Katherine d. Hon. William Brattle
John b. 1681	m	Anne d. Jos. Dudley
Anne b. 1686	m	Thomas Lechmere
Martha b. 1630	m	Thomas Lyon of Stanford
Mary b. 1612	m	Rev. Samuel Dudley
Adam b. 1620	m	dau. Rev. J. Glover
Deane b. 1632	m	dau. Rev. J. Glover

Margaret b. 1660	m	Jonathan Glover
Priscilla 1669	m	Eliab Adams
Mercy	m	Atherton Hough
Adam b. 1676	m	dau. Col. John Wainwright
Martha	m	Col. John Ballantine

Gentry × Officer Yeoman

Adam	m	dau. Capt. Thomas Hawkins
Deane b. 1632	m	(2) widow Capt. John Mellows
Elizabeth	m	Capt. Samuel Kent

Gentry × Yeoman

John (Fitz John)	m	dau. George Tongue of New London

THE *MAYFLOWER* PILGRIMS

SARAH LOUISE KIMBALL

What profit pedigree or long descents[1]
From farre-fecht blood, or painted monuments
Of our great-grandsire's visage? 'Tis most sad
To trust unto the worth another had
For keeping up our fame; which else would fall,
If, besides birth, there be no worth at all.
For, who counts him a gentleman whose grace
Is all in name, but otherwise is base?
Or who will honour him that's honour's shame,
Noble in nothing but a noble name?

It's better to be meanly born and good,
Than one unworthy of his noble blood:
Though all thy walls shine with thy pedigree,
Yet virtue only makes nobility.[2]
Then, that this pedigree may useful be
Search out the virtues of your family;
And to be worthy of your father's name,
Learn out the good they did, and do the same:
For, if you bear their arms, and not their fame,
Those ensigns of their worth will be your shame.

We claim for the descendants of the Pilgrims an especially pure, high minded type of character, exalted spiritually in an eminent degree.

Had it not been for the faith and courage of that little band of English exiles, the founders of Plymouth Colony, America would not have developed along the lines which have placed her in the lead among the nations of the world.

Prior to the landing at Provincetown, Cape Cod, on December 21, 1620, and on November 21, 1620, the famous Compact drawn up by William Bradford was signed in the cabin of the *Mayflower*.

Y^e COMPACT

IN THE NAME OF GOD, AMEN

We whose names are underwritten, the Loyall Subiects of our dread soveraigne Lord King Iames, by the Grace of God of Great Britaine, France, and Ireland King, Defender of the Faith, &c.

[1] Old Latin Verses quoted in Burke's "Patrician," iii, 63–4.

[2] Motto of California Genealogical Society.

Having under-taken For The Glory of God, and advancement of the Christian Faith, and honour of our King and Countrey, a Voyage to plant the first Colony in the Northerne parts of VIRGINIA, doe by these presents solemnly & mutually in the presence of God, and one of another, covenant, and combine our selves together into a Civill Body Politike, for our better ordering and preservation, and furtherance of the ends aforesaid; and by vertue hereof to enact, constitute and frame such just and equall Lawes, Ordinances, acts, constitutions, offices from time to time, as shall be thought most meet and convenient for the generall good of the Colony: unto which we promise all due submission and obedience.

In witnesse whereof we have here-under subscribed our names, Cape Cod, 11 of November in the yeare of the raiyne of our soveraigne Lord King Iames, of England, France and Ireland 18, and of Scotland 54. Anno Domini 1620.

	No. in family		*No. in family*
Mr. John Carver	8	John Turner	3
Mr. William Bradford	2	Francis Eaton	3
Mr. Edward Winslow	5	James Chilton	3
Mr. William Brewster	6	John Crackston	2
Mr. Isaac Allerton	6	John Billington	4
Capt. Miles Standish	2	Moses Fletcher	1
John Alden	1	John Goodman	1
Mr. Samuel Fuller	2	Degory Priest	1
Mr. Christopher Martin	4	Thomas Williams	1
Mr. William Mullins	5	Gilbert Winslow	
Mr. William White	5	Edmund Margeson	1
Mr. Richard Warren	1	Peter Brown	1
John Howland		Richard Britterige	1
Mr. Stephen Hopkins	8	George Soule	
Edward Tilley	4	Richard Clarke	1
John Tilley	3	Richard Gardiner	1
Francis Cook	2	John Allerton	1
Thomas Rogers	2	Thomas English	1
Thomas Tinker	3	Edward Doten	
John Ridgdale	2	Edward Leister	
Edward Fuller	3		

More than one-half of the company perished during the succeeding months and descent has been proven from but the following, namely:

1. John Alden[3]
2. Isaac Allerton[4]
3. John Billington[4]
4. William Bradford
5. William Brewster[4]
6. Peter Brown
7. James Chilton[4]
8. Francis Cooke[4]
9. Edward Doty
10. Francis Eaton[4]

[3] Includes descent from William and Alice Mullins and their daughter Priscilla.

[4] Includes descent from wife or child on the "Mayflower."

[5] Includes descent from John Tilley and his daughter Elizabeth.

11. Edward Fuller[4]
12. Dr. Samuel Fuller
13. Stephen Hopkins[4]
14. John Howland[5]
15. Richard More
16. Degory Priest
17. Thomas Rogers[4]
18. Henry Samson
19. George Soule
20. Myles Standish
21. Richard Warren
22. William White[4]
23. Edward Winslow

In contravention of the statement sometimes made, that the *Mayflower* Pilgrims were of the poorer and illiterate types of the English of that period, and of low social condition, the following are known to have been entitled to coat armor:

John Alden
Isaac Allerton, John Allerton
William Bradford
William Brewster
Francis Cooke
Edward Doty
Stephen Hopkins
John Howland
Myles Standish
Richard Warren
Edward Winslow, Gilbert Winslow

Ruskin says: "There is no wealth but life," and Tille, Forel and Saleeby tell us that "a nation is composed not of property nor of provinces, but of men."

In the interest of applied genealogy in relation to eugenics, a brief survey of the records of descendants of the Pilgrims shows that their names appear in places of highest honor and distinction in the history of America. Although not at all an exhaustive study of the subject, the following will indicate the value of the *Mayflower* spirit:

STATESMEN

	Lineage
John Adams,	son of John Adams and Susan Boylston
President United States	Joseph Adams and Hannah Bass
Member of Congress	John Bass and Ruth Alden
Minister to England	*John Alden*[6] and *Priscilla Mullins*[6]
	William Mullins[6] and *Alice*[6]
John Quincy Adams	son of John Adams and Abigail Smith
President United States	John Adams and Susan Boylston
Member of Congress	(*See above*)

[6] Passenger in the *Mayflower*.

Minister to The Hague Minister to England Minister to Portugal Minister to Prussia Minister to Russia	
Charles Francis Adams, Member of Congress Minister to England	son of John Quincy Adams and Louisa C. Johnson (*See above*)
William Bradford[6] Governor of Plymouth Colony	
John Carver[6] Governor of Plymouth Colony	
Henry Dearborn, Secretary of War Minister to Portugal	son of Simon Dearborn and Sarah Marston John Dearborn and Abigail Batchelder Nath'l. Batchelder and Deborah Smith John Smith, Jr. and Deborah Howland *John Howland*[6] and *Elizabeth Tilley* *John Tilley*[6]
James Abram Garfield, President United States	son of Abram Garfield and Eliza Ballou James Ballou and Mehitabel Ingalls Henry Ingalls and Sibyl Carpenter Jotham Carpenter and Mehitabel Thompson Jotham Carpenter and Desire Martin John Martin and Mercy Billington Francis Billington and Christine Penn *John Billington*[6] and *Ellen*[6]
Ulysses Simpson Grant, President United States	son of Jesse Root Grant and Harriet Simpson Noah Grant and Anna Buell Noah Grant and Susanna Delano Jonathan Delano and Amy Hatch Jonathan Delano and Mercy Warren Nathaniel Warren and Sarah Walker *Richard Warren*[6]
Frederick Dent Grant, Minister to Austria	son of Ulysses Simpson Grant and Julia Dent (*See above*)
Milton S. Latham, Governor of California Member of Congress	son of Bela Latham and Juliana H. S. Sterrett (1) Arthur Latham and Mary Port Nehemiah Latham and Lucy Harris (*See*) Arthur Latham and Alice Allen Chilton Latham and Susanna Kingman

Robert Latham and Susanna Winslow
John Winslow and *Mary Chilton*[6]
James Chilton[6] and *Mary*[6]

(2) Nehemiah Latham and Lucy Harris
Arthur Harris and Mehitabel Rickard
Isaac Harris and Jane Cooke (*See*)
Isaac Harris and Mercy Latham
Robert Latham and Susanna Winslow
(*See above*)

(3) Isaac Harris and Jane Cooke
Caleb Cooke and Jane ......
Jacob Cooke and Damaris Hopkins
Francis Cooke[6]

(4) Jacob Cooke and Damaris Hopkins
Stephen Hopkins[6] and *Elizabeth*[6]

(5) Arthur Harris and Mehitabel Rickard
Samuel Rickard and Rebecca Snow
William Snow and Rebecca Browne
Peter Browne[6]

Levi Parsons Morton,
Vice President United States
Governor of New York
Minister to France

son of Daniel O. Morton and ......
Levi Morton and ......
Ebenezer Morton and ......
Ebenezer Morton and ......
John Morton and Mary Ring
Andrew Ring and Deborah Hopkins
Stephen Hopkins[6] and *Elizabeth*[6]

Richmond Pearson
Envoy Extraordinary and Minister Plenipotentiary at Teheran, Persia

son of Richmond M. Pearson and ......
...... Pearson and Elizabeth Mumford
Robinson Mumford and ......
...... Mumford and Sarah Christophers
Richard Christophers and ......
Richard Christophers and Lucretia Bradley
Peter Bradley and Elizabeth Brewster
Jonathan Brewster and Lucretia Oldham
William Brewster[6] and *Mary*[6]

Elihu Root,
Secretary of State

son of Harrison Root and Caroline Holland
Park Holland and Esther Bridgman
Luther Holland and Betsey Spooner
Philip Spooner and Elizabeth Winslow
Kenelm Winslow and Elizabeth Clapp
Samuel Winslow and Mercy King
Kenelm Winslow and Mercy Worden
Kenelm Winslow and Eleanor (Newton) Adams
(brother of *Edward Winslow*[6])

Alphonso Taft,	son of Peter Rawson Taft and Sylvia Howard (*See*)
Attorney-General	(1) Aaron Taft and Rhoda Rawson
Secretary of War	Abner Rawson and Mary Allen
Minister to Russia	Edmund Rawson and Elizabeth Howard
Minister to Austria-Hungary	John Howard and Sarah Mitchell
	Experience Mitchell and Jane Cooke
	Francis Cooke[6]
	(2) Peter Rawson Taft and Sylvia Howard
	Levi Howard and ....
	Benjamin Howard and ......
	Benjamin Howard and ......
	John Howard and Sarah Mitchell
	(*See above*)
William Howard Taft,	son of Alphonso Taft and Louisa M. Torrey
Solicitor-General	Peter Rawson Taft and Sylvia Howard
Secretary of War	(*See above*)
Governor of the Philippines	
President United States	
Chief Justice Supreme Court	
Zachary Taylor,	son of Richard Taylor and ....
President United States	Zachary Taylor and Elizabeth Lee
	Hancock Lee, Sr. and Sarah Elizabeth Allerton
	Isaac Allerton and ....
	Isaac Allerton[6] and Fear Brewster
	William Brewster[6] and *Mary*[6]
Cadwallader Colden Washburn,	son of Israel Washburn and Martha Benjamin
Governor of Wisconsin	Israel Washburn and ......
Member of Congress	Israel Washburn and ......
	Israel Washburn and ......
	Samuel Washburn and Elizabeth Mitchell
	Experience Mitchell and Jane Cooke
	Francis Cooke[6]
Charles Ames Washburn,	son of Israel Washburn and Martha Benjamin
Minister to Paraguay	(*See above*)
Elihu Benjamin Washburn,	son of Israel Washburn and Martha Benjamin
Member of Congress	(*See above*)
Secretary of State	
Minister to France	

Emory Washburn, a descendant of *Francis Cooke*[6]
Governor of Massachusetts

Daniel Webster,	son of Ebenezer Webster and Abigail Eastman
Secretary of State	Ebenezer Webster and Susanna Batchelder

Benjamin Batchelder and Susanna Page
Nathaniel Batchelder and Deborah Smith
John Smith, Jr., and Deborah Howland
John Howland[6] *and Elizabeth Tilley*
John Tilley[6]

Edward Winslow[6]
Governor of Plymouth Colony

Josiah Winslow[6]
Governor of Plymouth Colony

Leonard Wood,
Governor of Cuba
Governor Philippines

son of Charles J. Wood and Caroline E. Hager
Leonard Wood and Malvina Fitzalan Reed
Noah Reed and Susannah White
Micah Reed and Deborah Tomson
Daniel Reed and Ruth White
William Reed and Alice Nash
William Reed and Esther Thomson
John Thomson and Mary Cooke
Francis Cooke[6]

Also a descendant of
William Brewster[6]
Stephen Hopkins[6]
William White[6]

CHIEF JUSTICES

Sir John Singleton Copley, Jr.,
Baron Lyndhurst,
Lord High Chancellor of England

son of John Singleton Copley and Susanna Farnum Clarke
Richard Clarke and Elizabeth Winslow
Edward Winslow and Eliz. Pemberton
a descendant of
John Winslow and *Mary Chilton*[6]
James Chilton[6] and *Mary*[6]

Melville Weston Fuller,
U. S. Supreme Court

son of Frederick Augustus Fuller and Catherine Martin Cony
Henry Weld Fuller and Esther Gould
Caleb Fuller and Hannah Weld
Young Fuller and Jerusha Beebe
Matthew Fuller and Patience Young
Samuel Fuller, Jr., and Anna Fuller
Samuel Fuller and Jane Lathrop
Edward Fuller[6] and *Anne*[6]

William Howard Taft (see Statesmen)
U. S. Supreme Court

SIGNERS OF THE DECLARATION OF INDEPENDENCE

	Lineage
Abraham Clarke,	son of Thomas Clark and ......
Member of Congress	Thomas Clark and ......
	Richard Clark and ......
	Richard Clark and ......
	Richard Clarke[6]
Robert Treat Paine,	son of Rev. Thomas Paine and ......
Member of Continental Congress	James Paine and ......
	Thomas Paine and Mary Snow
	Nicholas Snow and *Constance Hopkins*[6]
	Stephen Hopkins and (1) ......

LITERATURE

Charles Edward Banks, M.D.,	son of
Banks Family of Maine	(1) Edward Prince Banks and Ellen Soule
Martha's Vineyard, Etc.	Charles Soule and Phebe Bartol (*See*)
	Moses Soule and ......
	Moses Soule and ......
	Barnabas Soule and Jane Bradbury
	Moses Soule and Mercy Southworth
	Edward Southworth and Mary Pabodie
	William Pabodie and Elizabeth Alden
	John Alden[6] and *Priscilla Mullins*[6]
	William Mullins[6] and *Alice*[6]
	(2) Charles Soule and Phebe Bartol
	George Bartol and Jane Soule
	Barnabas Soule and Jane Bradbury (*See above*)

George Ernest Bowman, a descendant of *William Brewster*[6]
The *Mayflower* Descendant

William Bradford[6]
The Log of the *Mayflower*

William Brewster,[6]
The *Mayflower* Compact

William Cullen Bryant,	son of Peter Bryant and Sarah Snell
Poet	Philip Bryant and Silence Howard
	Abiel Howard and Silence Washburn
	Nehemiah Washburn and ......
	John Washburn and Elizabeth Mitchell
	Experience Mitchell and Jane Cooke
	Francis Cooke[6]

Winston Churchill,
Richard Carvel
The Crisis
The Crossing, etc.

son of
(1) Edward Spalding Churchill and Emma Bell Blaine
Edwin Churchill and Mary Phipps Carter
James C. Churchill and Eliza W. Osborne
Thomas Churchill and Alice Creighton
Thomas Churchill and Mary Stuart Ewes
Barnaba s Churchill and Lydia Harlow
William Harlow and Lydia Cushman (*See*)
William Harlow and Rebecca Bartlett
Robert Bartlett and Mary Warren
Richard Warren[6]

(2) William Harlow and Lydia Cushman
Thomas Cushman and *Mary Allerton*[6]
Isaac Allerton[6] and *Mary Norris*[6]

Fanny Jane Crosby,
Hymn writer

daughter of John Crosby and Mercy Crosby, dau. of
Sylvanus Crosby and Eunice Paddock
Isaac Crosby and Mercy Foster
Eleazer Crosby and Patience Freeman
John Freeman and Mercy Prence
Thomas Prence and Patience Brewster
William Brewster[6] and *Mary*[6]

William Howard Doane,
Hymns and hymnals

a descendant of *William Brewster*[6]

Ralph Waldo Emerson,
Essayist, poet

son of William Emerson and Ruth Haskins
John Haskins and Hannah Upham
Phineas Upham and Hannah Waite
Joseph Waite and Lydia Sargent
John Sargent and Lydia Chipman
John Chipman and Hope Howland
John Howland[6] and *Elizabeth Tilley*
John Tilley[6]

Josiah Gilbert Holland,
Springfield Republican
Scribner's, Etc.

son of Harrison Holland and Anna Gilbert
Luther Holland and Betsey Spooner
Philip Spooner and Elizabeth Winslow
Kenelm Winslow and Elizabeth Clapp
Samuel Winslow and Mercy King
Kenelm Winslow and Mercy Worden
Kenelm Winslow and Eleanor (Newton) Adams
(brother of *Edward Winslow*[6])

Henry Wadsworth Longfellow,
Poet

son of
(1) Stephen Longfellow and Zilpah Wadsworth
Peleg Wadsworth and Elizabeth Bartlett (*See*)

Peleg Wadsworth and Susannah Samson
John Samson (*See*) and Priscilla Bartlett
Benjamin Bartlett and Ruth Pabodie (*See*)
Benjamin Bartlett and Sarah Brewster
Love Brewster[6] and Sarah Collier
William Brewster[6] and *Mary*[6]
(2) Peleg Wadsworth and Elizabeth Bartlett
Nathaniel Bartlett and Zenobe Wadsworth
Ebenezer Bartlett and ......
Ebenezer Bartlett and ......
Benjamin Bartlett and Sarah Brewster
(*See above*)
(3) John Samson and Priscilla Bartlett
Stephen Samson and ......
Henry Samson[6]
(4) Benjamin Bartlett and Ruth Pabodie
William Pabodie and Elizabeth Alden
John Alden[6] and *Priscilla Mullins*[6]
William Mullins[6] and *Alice*[6]
(5) Benjamin Bartlett and Sarah Brewster
Robert Bartlett and Mary Warren
Richard Warren[6]

Percy MacKaye, Playwright
a descendant of *William Bradford*[6]

Frank Munsey, Author, publisher
a descendant of *Stephen Hopkins*[6]

John Howard Paine, Home, Sweet Home
son of William Paine and ......
William Paine and ......
John Paine and ......
Thomas Paine and Mary Snow
Nicholas Snow and *Constance Hopkins*[6]
Stephen Hopkins and (1)......

Benjamin Franklin Soule, Annals of San Francisco
son of Charles Soule and Anne Kendall
Moses Soule and Nancy Hewes
Barnabas Soule and Jane Bradbury
Moses Soule and Mercy Southworth (*See*)
John Soule and Rebecca Simmons
George Soule[6]
(2) Moses Soule and Mercy Southworth
Edward Southworth and Mary Pabodie
William Pabodie and Elizabeth Alden
John Alden[6] and *Priscilla Mullins*[6]
William Mullins[6] and *Alice*[6]

Mrs. Mercy Otis Warren, Historian
daughter of James Otis and Mary Allyn
Joseph Allyn and Mary Doty

		Edward Doty and Sarah Faunce
		Edward Doty[6] and Faith Clarke
Noah Webster, Lexicographer	son of	Noah Webster and Mercy Steele
		Eliphalet Steele and Catharine Marshfield
		Samuel Steele and Mercy Bradford
		William Bradford and ......
		William Bradford and Alice Richards
		William Bradford[6] and Alice Carpenter

From the foregoing records it will be plainly seen that the ideals of the *Mayflower* Pilgrims—freedom of the soul, freedom of the mind, the germ of our free institutions—have become a part of our national life.

Daniel Webster, the gifted statesman and orator, a descendant of the Pilgrims, in an address on the first settlement of New England causes the Pilgrims when they landed upon Plymouth Rock to use the following language:

> If God prosper us, we shall here begin a work which shall last for ages; we shall plant here a new society, in the principles of the fullest liberty and the purest religion; we shall subdue this wilderness which is before us; we shall fill this region of the great continent, which stretches almost from pole to pole, with civilization and Christianity; the temples of the true God shall rise where now ascends the smoke of idolatrous sacrifice; fields and gardens, the flowers of summer and the waving and golden harvest of autumn, shall spread over a thousand valleys, never yet, since the creation, reclaimed to the use of civilized man. We shall whiten this coast with the canvas of a prosperous commerce; we shall stud the long and winding shore with a hundred cities. That which we sow in weakness shall be raised in strength. From our sincere, but houseless worship, there shall spring splendid temples to God's goodness; from the simplicity of our social union, there shall arise wise and politic institutions of government, full of the liberty which we ourselves bring and breathe; from our zeal for learning, institutions shall spring which shall scatter the light of knowledge throughout the land, and, in time, paying back where they have borrowed, shall contribute their part to the great aggregate of human knowledge; and our descendants, through all generations, shall look back to this spot and to this hour, with unabated affection and regard.

From Governor Bradford's "Log of the Mayflower" down to "The Mayflower Descendant," by George Ernest Bowman, the records of the Pilgrims have been carefully preserved, covering a period of three hundred years.

Many other distinguished names might be added to the foregoing list of eminent Americans tracing their ancestry to the *Mayflower*, but those mentioned are sufficient to show that the spirit of freedom brought to our shores in 1620 by the founders of Plymouth Colony has been a determining factor in our national development, leading all endeavors along a high, spiritual path and bringing to our beloved country its present full measure of liberty, wealth and happiness.

THE LEARNED BLACKSMITH—AN ARISTOGENIC TYPE

HOWARD J. BANKER

Eugenics Record Office, Cold Spring Harbor, New York

Elihu Burritt was long known as the "Learned Blacksmith." He acquired a knowledge of over thirty languages, some say fifty (5), while laboring daily at the forge. With slight educational advantages, his parents poor and the family believed to be obscure and of mediocre ability, many have regarded him as an example of what may be accomplished by the most unfavored if one but tries and perseveres. Others consider him an inexplicable, spontaneous genius, or human sport. Such instances are often cited as evidence of the impotence of heredity.

The biographers of Burritt, who draw nearly all their material from his own writings, give little information concerning his family. Like many another genius Burritt saw his attainments as only the result of close application and determined perseverance which he believed possible to any one of ordinary intelligence and reasonably good health. His first public essay was to prove that there was no native genius.

Without taking space to array the evidences from his life and writings we may briefly enumerate his most striking characteristics. He was a man of remarkable energy, active and restless, both physically and mentally. He was intensely hyperkinetic. As a boy he read all the historical and biographical books in the village library of a few hundred volumes (3, 5). He worked at the forge twelve and fourteen hours a day and found time for study (3). He carried a Greek grammar in the crown of his hat that he might con the verbs while heating his iron (1). He left his forge in order to study and taught for a time. The change affected his health and he became a commercial traveller. He then started a grocery, failed, and walked from New Britain, Conn., to Boston intending to go to Europe in pursuit of his language studies, missed the boat and went to Worcester, returned to the forge and studied at the library of the Antiquarian Society, attracted attention by his linguistic powers, became known as the "Learned Blacksmith," began lecturing and edited a paper, advocated anti-slavery and temperance but chiefly international peace, travelled in Europe for three years, then over the United States and back to Europe promoting the peace

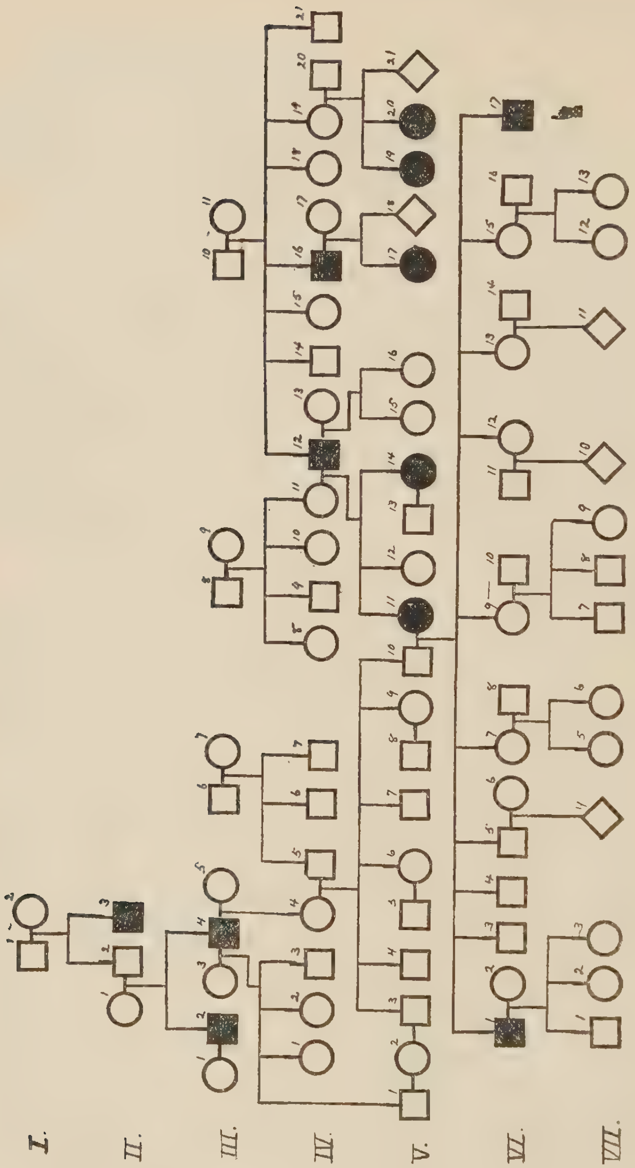
cause, returned to his home in New Britain at the age of fifty "without resources" and operated a small stony farm. He organized an Agricultural Club and during the Civil War returned to England and travelled on foot from London to John O'Groat's studying agriculture, took other long foot tours (1), and so I might continue to show the restless energy of the man, the wanderlust and the changing activities. Altogether he published some thirty books on a great variety of topics besides a great many contributions to journals (2).

It can not be said that Elihu Burrett was a profound, and it is doubtful if he was an original, thinker. He was by no means a Leibnitz. He had a lively intellect and great facility of expression. While laboring at the forge his mind demanded active exercise but there is no evidence that it ever took an inventive turn. He wrote books of religious meditation (1) but nothing to satisfy the philosophical questionings of the human soul. He wrote grammars for beginners in Sanskrit, Hindustanee, Persian and Turkish (5) but his vast fund of languages resulted in no great comparative philology. Great and wonderful as the man was he appears to have had definite limitations and his abilities appear to have been simple in character but extraordinary in extent.

He unquestionably had a remarkable verbal or symbolic memory. When he first began work at the forge before he engaged in the study of language, to relieve the mental restlessness, he undertook successfully the purely mental calculation of such problems as: "How many yards of cloth, three feet in width, cut into strips an inch wide and allowing half an inch at each end for the lap, would it require to reach from the center of the sun to the center of the earth, and how much would it all cost at a shilling a yard?" (1) He could recite whole cantos of Scott and Moore (4). His memory doubtless did him great service in his linguistic studies.

He was benevolent and an idealist. The most of his life was devoted to the cause of promoting international peace, the bulk of his writings was in the interest of social reform and human betterment, in his last years he built mission chapels and conducted Sunday Schools (2).

Consider now the quarry whence this character was built. Elihu had nine sibs of whom we know almost nothing except of the eldest, Elijah, and very little about him. Elijah (VI. 1) became a blacksmith studying at the same time mathematics. His ardor in this subject induced some friends to assist him to enter college (3) and he was in attendance at Williams for a time (4). Like Elihu, who was given a similar opportunity at Harvard, he could not restrict himself to a college curriculum. Leaving college he went south, taught school and became editor of a newspaper in Milledgeville,



PEDIGREE CHART

Georgia. His attitude on the slavery question gave offence and he was forced to flee for his life. Returning north he established a school of some prominence in his native town. He was the author of a number of school books, his "Geography of the Heavens" passing through numerous editions and being used long after his death. He eventually went to Texas as the head of a small colony and there died. One of his students says, "He was a man of great energy of character, of a commanding presence, much given to ostentation and display, imperious in his manner, and too fond of change and adventure to make the success in life which his great talents would otherwise have accomplished"(4). Another writer says he "was a man of more than ordinary talents, but somewhat erratic" (7).

The sister, Eunice (VI. 9), after the death of her first husband, "went west as a teacher, under the patronage of Governor Slade," was saved from a wreck on the Lakes by "her coolness and intrepidity," and later married a professor in the old Chicago University (6). She may have been a person of intellectual activity but we know too little about her to express an opinion.

Isaac (VI. 3) lived near his native town. A contemporary has written, he "makes himself useful to church and society, has been a school teacher, and is earnest in every good work, has a gift in prayer, exhortation, and off-hand speaking in public" (7).

George (VI. 4) "a young man of good promise" went south and died in Georgia (7).

Of the remaining sibs we know nothing but the fact of marriage and dates. The study of his fraternity, meager though it be, shows that Elihu was not alone in some of his striking characteristics.

The father, Elihu Burritt (V. 10), says Mary Howitt, had a hard life, "but his troubles and difficulties never soured the milk of his human kindness." His home though small and full of its own inmates sheltered "more benighted travellers than any other home in the town." The halt, the blind, the dumb and even the friendless and idiotic pauper became uncle or aunt and found a place within the family circle though having no other claim than their misery. Many a time returning on foot from market ten miles away the good shoemaker would walk two or three miles out of his way to bring cheer to some helpless sufferer (3). The son says he was "a man of nervous temperament, quick apprehension and vivid sympathies" (3). Another says he was "a man of active and speculative mind, scrupulously honest and moral"(6). We seem to see here the pronounced benevolence of the son, perhaps something of the nervous energy and perchance the rudiments of the foot tours of England.

Of the father's fraternity we have practically nothing but genealogical data. One sister, Naomi (V. 6), taught school before her marriage," was social and intelligent, possessing a discriminating mind" (6). The father's father and family (IV. 5–7 etc.) are seemingly lost in hopeless obscurity. We can only guess at the connection (12). The obscurity of this Burritt line has tinged the whole history of Elihu Burritt as it is a common fallacy to think of a man's ancestry as only in the line of the name that he bears.

His father's mother, Eunice Wakeman (IV. 4), had no full sibs. Of her and her half fraternity we know nothing of importance (6, 9). Her father (III. 4) was a graduate of Yale (9) and had a brother (III. 2), a graduate of Yale and an uncle (II. 3) a graduate of Harvard (14). They do not appear to have been otherwise men of great prominence. The members of this college group are doubtless too remote to have greatly influenced Elihu Burritt. What they may have contributed genetically to him it is impossible to say but it seems reasonable to believe that they served to raise somewhat the intellectual average of the Burritt line.

The mother (V. 11) of Elihu Burritt appears to have been superior to the average of her social class. The son and his biographers dismiss her with the respectful platitude, "She was the best friend her children had," mention "the influence of her prayers" and "the teachings of her godly life" (3). One writer, however, gives an additional touch saying that "she was a devout Christian woman of many resources, who could turn her hand to almost anything" and describes the garden with its abundance of vegetables and great variety of flowers; the order, neatness and comfort of the home, the group of mulberry trees and the cultivation of the silk-worm to which she devoted one room of the little house (4). Another writer quaintly remarks, "She was equally well versed in the Bible as in the silk business" (6).

An illuminating incident is told of the boy's visits with his mother to the village library where a few books of sermons and history could be had but as books could be drawn only once in two months, he endeavored to persuade his mother to relinquish her book of sermons that he might have one more of history but only occasionally did he succeed (3). This is related by the biographer to emphasize the son's intellectual ardor but how much does it also reveal the mother's strong intellectual hunger. And it may be significant that it was not the father in whom the boy found this intellectual sympathy.

The mother had no brother and but one sister who lived to maturity—Roxana Hinsdale (V. 14). We know little of this sister but one statement concerning her is enlightening. She left at her death "some interesting written reminiscences of her own religious experience and life" (7). That

a New England farmer's wife with twelve children to care for should be impelled to write of her spiritual experiences would indicate that she possessed strong mental activities. Her son wrote several extensive genealogies and a local history. These two sisters evidently were endowed with some intellectual potentialities. There were two half sisters (V. 15, 16) but nothing has been learned of them.

The mother's father, Elijah Hinsdale (IV. 12), learned the blacksmith's trade but later owned a farm and engaged extensively in silkworm culture, receiving for many years a bounty from the state which was seeking to encourage this industry (6, 8). James Freeman Clark is quoted as saying that "he was a remarkable man, ... a great reader, and with only ordinary advantages, possessed of an extraordinary fund of knowledge," and adds "His wonderful love of learning and a capability of retaining it will undoubtedly be found to have been handed down to the Hinsdales and throughout the various branches of their descendants as far as it can be traced" (7). This prediction is in part fulfilled in Elihu Burritt.

Of the mother's father's fraternity we have significant data only of Theodore (IV. 16). He was a graduate of Yale and ordained to the ministry. He was a man "of marked ability and strong will and an active man of affairs" (7). The town of Hinsdale, Mass., was named for him. Until his death at the age of eighty "he read the classics with perfect ease and could quote them readily" (11). His eldest daughter, Anne, "established the first young ladies' school in Pittsfield, Mass.," which she conducted for many years and was later a teacher in connection with her cousin, Mrs. Willard (7).

Of the rest of this fraternity little material is at hand except genealogical data, but Lydia Hinsdale (IV. 19) who married Samuel Hart was the mother of ten children including Emma Hart Willard (V. 19) famous as an educator and the founder of the Emma Willard Seminary of Troy, New York, and her sister, Almira Lincoln-Phelps (V. 20), only a little less eminent as an educator and the author of text-books highly regarded in their day (7).

The father of this Hinsdale group was John Hinsdale (III. 10). He was a blacksmith and owned a farm in Berlin, Conn. He was ensign, lieutenant and captain in the local militia and prominent in the community. He is described as a "man of rare military and literary ability," but we have little definite data concerning him (7). While this is suggestive it is hardly sufficient ground for any very positive assertions.

In respect to Elihu Burritt's mother's mother Ruth Bidwell (IV. 11) we know little. She died at thirty-three "supposed to have been poisoned by a negro slave woman." Of her family we have practically nothing but some scant genealogical data. Her only brother died of consumption in Virginia (10).

Reviewing the family network as a whole we see in the ancestral inheritance of Elihu Burritt two rather distinctly differentiated types. On the paternal side there appears throughout a good wholesome stock of mediocre ability and with no great apparent potentialities. Doubtless important factors in the personality of the propositus are contributed from this side but it is difficult to identify them with certainty and to trace their distribution. His absorbing benevolence and possibly something of his nervous energy are derived here. What else we can hardly suggest. On the maternal side we find a stock that is repeatedly putting forth individuals of distinct intellectual activities. What combinations were essential to call these out we may not know but it is evident that intellectual potentialities are carried in the germ-plasm of the maternal network. In Elihu Burritt this intellectual capacity found its expression through a combination of factors that gave rise to the unique accomplishments of the "Learned Blacksmith." He was not the spontaneous product of a barren soil, the extraordinary fruition of a sterile heredity; on the contrary he was in large degree if not wholly the outgrowth of interlacing hereditary streams rich in the essential elements that constituted his personality.

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BREVE RESEÑA GENEALOGICA DE LA FAMILIA IZQUIERDO

J. JOAQUIN IZQUIERDO

Después de largas y pacientes investigaciones he logrado llegar a reunir una serie de datos relativos a mis antecesores, que me han servido para formar el arbol genealógico de mi familia, que va adjunto, así como otras muchas noticias que espero reunir en un próximo libro. Los felices resultados de mi investigación son enteramente nuevos, pues, con excepción de lo relativo a las tres últimas generaciones, los demás datos que presento eran totalmente desconocidos para las personas de mi familia, especialmente los que se refieren a las generaciones españolas. El único recuerdo, vago y borroso, conservado por algunas de las personas de mayor edad que aun viven, era el de que alguno de los antecesores, oyendo que en cierta ocasión sus hijos hacían tal o cual comentario sobre ciertos papeles nobiliarios de familia, que él guardaba, tras de reprenderlos ásperamente por poner tanto interés en cosas tan mundanas, había entregado los papeles al fuego. Verdadero o falso este hecho, lo cierto es que mi familia no poseía ninguno de los datos que hoy ofrezco. Si a pesar de mi espíritu liberal y propenso a mirar hacia el porvenir más bien que a vivir queriendo alentar tan sólo por el impulso del pasado, hago esta investigación y pongo en ella cierto cariño, es porque a más del interés histórico que creo encontrarle, pienso que bien puede aplicarse a su orígen lo que César Cantú dijo de la nobleza portuguesa, derivada en gran parte, como en el caso de que nos vamos a ocupar, de los que habían combatido en la famosa batalla de Ourique: "que no se apoyó en la conquista ni en el feudalismo, sino en las cualidades personales, en el valor, en la lealtad, en la religión."[1] Por eso fué que, cuando depués, libre ya Portugal de toda dominación extrangera en virtud de la decisión del Papa Alejandro III que concedía a Alfonso Enríquez el título de Rey, que le disputaba el Rey de Castilla, y todas las tierras que pudiera quitar a los Moros, al reunirse las cortes de Lamego, en las que estaban representados el alto clero, la nobleza y los diputados de las diez y seis ciudades principales del reino, después de sancionar la elección que había hecho el ejército de Alonso Entíquez, por su Rey, y de coronarlo, al proceder a formar sus leyes y contar entre ellas las relativas al modo de componer la nobleza, las apro-

[1] César Cantú. Historia Universal. Cap. XIX, págs. 155y 157 del tomo XXII de la edición española de Gassó Hermanos, Barcelona.

ARBOR GENEALOGICO

baron "porque les parecieron *buenas* y *justas*, doble condición sobradamente olvidada en tiempos más cultos y refinados" (Cantú).

ORIGEN

En los tiempos en que Alfonso Enríquez, hijo de Enrique de Borgoña y de Teresa, hija del Rey Alfonso I de Portugal a quién aquel, en unión de otros caballeros franceses había ido a socorrer, dominaba con el título de Duque el país que se extiende entre el Miño, el Duero y Tras-Os-Montes, y que de Porto-Cale, antigua capital de los gallegos, fué llamado Portugal, refiere Fray Jaime Bleda[2] en su "*Corónica de los Moros de España,*" que "en el año de mil y ciento treynta y nueve, el Moro Ismael mató al Rey de Badajoz, y se alçó con aquel Reyno, y juntando vn buen exercito con ayuda de otros caudillos Moros, entró en Portugal: mas el Duque Don Alonso Enríquez le salió al encuentro, y en el campo de Ourique, cerca de Castro Verde, le dió batalla y le venció: y el Moro boluió desbaratado a Badajoz." Y añade "que esto cuentan con esta brevedad las historias arabescas, pero que las portuguesas dicen que el Duque salió de la ciudad de Coimbre, y atravesando el río Tajo, començó a hazer guerra a los Moros, y Ismael y otros quatro caudillos Moros, salieron a la defensa de sus tierras contra el Duque. Assentó el buen Principe su Real en el campo de Ourique, cerca de Castro Verde: donde agora llaman cabeças de los Reyes, a vista del exercito de los infieles y aunque los suyos quisieron escusar la batalla, vista la multitud de los Moros, él los animó exortándoles con muy eficaces razones, y con maravilloso valor y esfuerço: conque todos seaprestaron para dar la batalla, con animo de morir en la defensa de la Sancta fé. Era este día a veynticinco de Julio, fiesta del glorioso apostol Santiago el Mayor, y assi muchos se confessaron, y comulgaron, era Martes de dicho año. Allí acordaron todos, de alçar por Rey al Duque Don Alonso Enríquez su Señor por entrar en la batalla con mayor ánimo. Dizen las historias Portuguesas, que todos a bozes aclamauan: Portugal: Portugal por el Rey don Alfonso Enríquez y desta forma fué alçado por Rey del inclyto Reyno de Portugal." Con lo cual "quedaron muy alegres los Portugueses y luego ordenaron los esquadrones, que en número eran muy inferiores a los de los enemigos, y arremetiendo contra ellos denodadamente, y ceuándose en aquella bárbara gente, enemiga del nombre Christiano, mataron muchíssimos dellos, y tomando los cinco estandartes y pendones de los Reyes Moros, fué glorioso vencedor el nuevo Rey don Alonso Enríquez."

[2] Fray Jaime Bleda. Corónica || de los Moros || de España. Diuidida en ocho Libros || Con Licencia. || En Valencia, en la Impressión de Felipe Mey. || Año 1618.

En un nobiliario de Zazo, rey de armas que coleccionó mucho, existente en el departamento de manuscritos del Archivo Histórico de Madrid, (tomo XVIII, pág. 838), se refiere que "Don Diego de Guipuzcoa, el año de 1139; llevando en la batalla de Ourique un estandarte, peleó tanto con los Moros que fueron a quitársele, en cuya defensa perdió el brazo derecho y peleó como pudo con el izquierdo, sin soltar el estandarte, asistiendo en toda la batalla hasta que se venció por el Rey D. Alonso I de Portugal, por cuyo hecho le empezaron a llamar el Izquierdo, cuyo cognomen le puso dicho Monarca, y le hizo grandes Mercedes. Y dió heredamientos con lo que se retiró a su tierra que era en las Montañas de Burgos, y allí fundó un solar y casa en el Valle de Sedano que es el primitivo de esta familia; sus descendientes fundaron otra en el lugar de Alcolea situada en la Rivera del Río Sinca dos leguas de Segena y cuatro de Monzon; otra en la villa de Cariñoso sita entre Daroca y Zaragoza, otra en Extremadura, *otra en Castilla la Vieja*, *tierra de los Cameros*, y otras muchas que hay en España. Los más usan unas Armas que son de rojo; con vanda de plata en vocas de dragantes verdes, lampazados de oro con dos estrellas de oro, una encima de la vanda y otra abajo."

GENERACIONES ESPAÑOLAS

Vuelto ya en su solar castellano de Burgos, el fundador de la familia se desvanece, manco y glorioso, en los remotos evos de su tiempo. Ninguna otra noticia es dable encontrar con relación a él o a sus inmediatos descendientes debido a que en aquellas épocas aún no existían los archivos parroquiales, que no empezaron a llevarse sino hasta la primera mitad del siglo XVI.

Sin embargo, sábese que por los Siglos XIV ó XV, *Don Juan Izquierdo de Roças*, *Señor de las Torres de Roças*, en el Valle de Soba,—(sólo era señor de la Torres de Roças y no del pueblo que, como todo el Valle de Soba, pertenecía a los condestables de Castilla. Condes de Haro),—y *Patrono de su Iglesia*, era descendiente de Don Diego, según lo atestigua la identidad de sus armas, sólo diferentes de las de aquel, por los esmaltes de las cabezas se dragantes que en vez de sinoples se vuelven de oro, y de los rayos de las estrellas, que se precisan ser en número de diez.

Fué sin duda Don Juan Izquierdo de Roças el que escribió en derredor de las armas de familia, el lema heráldico que resume su historia, relatando en virtud de que hechos se había hecho valer y a costa de que sacrificios había logrado construir su morada:

De Rodas vine rodando
Y a Roças llegué rodando.
De Rodas vine rodando
Y a Roças Yze de nada
Y con sangre derramada.

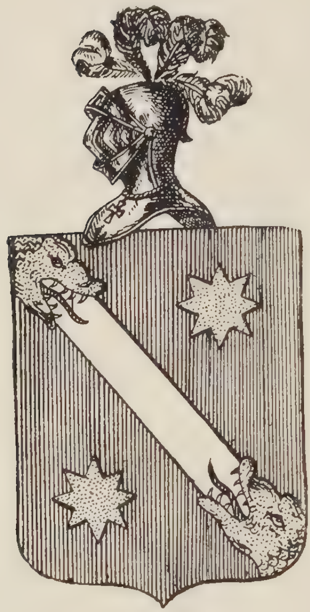


FIG. 1. ARMAS DE LA FAMILIA IZQUIERDO

Aunque no he podido encontrar dato alguno que permita explicar estas palabras, creo leer en ellas una alusión muy clara a la famosa isla de Rodas, de la que se apoderaron los caballeros de San Juan de Jerusalen en 1310. Me parece muy probable que Don Juan Izquierdo de Roças haya estado entre aquellos esforzados conquistadores, y no me sorprendería que posteriores investigaciones me llevasen a encontrarle concurriendo a la consumación de la obra, en 1310. Y lo repito, aunque no he podido averiguarlo. Es muy probable que si no en aquel gran hecho, sí haya asistido a algún otro, pues bien claro lo dicen sus palabras: *De Rodas vine rodando*, es decir de un lugar a otro, sin fijarse en sitio determinado, hasta que llegado al Valle de Soba, *a Roças hace de nada y con sangre derramada*, con lo cual quiere perpetuar en su linage los esfuerzos que hiciera en Rodas. El nom-

bre mismo de Roças parece indicarlo: No es muy elocuente la analogía entre *Rodas*, formado del griego ῥόδον, rosa, y *Roças*, el nombre que pone a su casa, de igual significado castellano?

Se ignora con quién casó Don Juan Izquierdo de Roças, pero se sabe que fué padre de *Don Sancho Izquierdo de Roças*, cuyas fechas de nacimiento y muerte no es posible conocer por la falta de archivos parroquiales. De Don Sancho, se sabe que casó en Villoslada de Cameros, del Reino de Castilla la Vieja, en la actual provincia de Logroño con Doña *Catalina Martínez de Azagra y Fernández de Velasco* y que de esta unión arranca la rama de descendientes de Don Diego de Guipuzcoa, apellidado el Izquierdo, que vimos mencionar a Zazo *en tierras de los Cameros, de Castilla la Vieja*, de donde derivan, según puede verse en el arbol genealógico que he formado, tanto la rama de los ascendientes del autor, como la de los López Izquierdo Montenegro, de los que proceden los actuales López Montenegro, de España, y la del Barón de Maabe a que más adelante me referiré.

En efecto, de sus hijos, *Diego Izquierdo de Roças*, que casó en Villoslada con *Francisca Sánchez Salvador*, dió origen a la rama de donde más tarde había de salir la familia mexicana (rama Izquierdo Ruiz), y por intermedio de su hijo Alonso, a la del Barón de Maabe; su hermano *Sancho Izquierdo de Roças*, que casó en Villoslada con Mariá Rodriguez, dió el tronco de los López Izquierdo Montenegro.

Tuvo por hijos, Diego Izquierdo, a *Diego Izquierdo*, casado con *María García de Olalla*, y a Alonso Izquierdo, nacido el 16 de abril de 1545, que es el continuador de la rama del Barón de Maabe, y que hacemos figurar en el arbol que he formado, porque una certificación de armas extendida a su hijo Marcos Izquierdo Montenegro, es la que nos servirá para relacionar a estos Izquierdo con los primitivos de que ya hemos hablado.

A partir de esta época ya empezamos a contar con datos más precisos, porque hallándonos a principios del Siglo XVI, empiezan a llevarse los libros parroquiales, que en Villoslada existen a partir de los mil quinientos cuarenta.

Ya hemos dicho que Don Diego Izquierdo y Sánchez Salvador, fué hermano de Don Alonso Izquierdo, casado con Doña María de Montenegro, de cuyo matrimonio resultó Marcos Izquierdo Montenegro, nacido el 4 de mayo de 1580, primo de Diego Izquierdo García de Olalla, según lo demuestra su partida de nacimiento, que dice: "a 4 de mayo de 1580, yo el lic^{do} López baptacé a Marcos, hijo de Alonso Hizquierdo y de M^{ia} de Montenegro su muger, sus abuelos Di° Hizquierdo y Antonio de Montenegro, vecino de Vinuesa, su padrino el lic^{do} Hizquierdo." (folio 16, vuelta, del tomo V, del libro de bautizados, finados y casados de la parroquia de N.

Sra. del Sagrario de la villa de Villoslada de Cameros, Obispado de Calahorra y La Calzada, Provincia de Logroño, España).

La descendencia de Alonso Izquierdo, hasta el Barón de Maabe, es como sigue:

Don Juan Izquierdo de Roças

Don Sancho Izquierdo de Roças × Catalina Martínez de Azagra, etc.

Diego Izquierdo de Roças × Francisca Sánchez Salvador

Alonso Izquierdo × María de Montenegro

Marcos Izquierdo × María Izquierdo de Jiménez de Enciso

Alonso Izquierdo × Margarita López de Arcos Salazar (en Nájera)

Alonso Izquierdo × Clara de Urturi y López de Arcos Salazar

Ignacio Izquierdo × Petronila de Maturana y Ruiz de Otazu

Narcisa Izquierdo, casada con Ignacio de Medrano, *Barón de Maabe.* × Andrea Izquierdo, casada con Joaquín López Montenegro y Fernández de Velasco. Bendiciones 1743.

En el archivo del Señor Don Federico Velaz de Medrano y López Montenegro, Barón de Maabe y Caballero de Calatrava, existe el original de una certificación de armas, que, según copia que debo a la gentileza de dicho señor, dice así:

Yo Domingo Gerónimo De Mata Criado del *Rey* nuestro Señor Don *Phipe* quarto deste nombre y su Rey de armas.

Certifico y hago entera fee y crédito a todos los que la presente vieren que las armas y blasón del apellido y linage de *Izquierdo* son las que van aquí con la verdadera razón como parece por los libros y copias de linages que blasonan de los solares y armas nobles de España de mi officio que en mi poder están, de donde lo saqué en la forma que sigue.

Los de este linage de *Izquierdo* son naturales de las Montañas buenos hijosdalgo de donde han salido a diferentes partes y lugares ay de ellos en Castilla la bieja y en la Rioja y en el Andalucía y en otras partes. Traen por *armas* un escudo de goles y en el una banda de plata con Dragantes de Oro con apartamientos de metales y en la parte de arriba sobre la banda un lucero de Oro de diez Rayos y en la parte de abaxo otro lucero de otros diez Rayos de Oro y estas son sus armas.


Yo Domingo Jerónimo De
Mata
Rey nuestro Señor Don
Philipe quarto deste
y su Rey de armas
Certifico y hago entera

FIG. 2

Las Quales dichas armas y apellido están puestas y escritas en el libro quinto de blasones a fojas trescientas y noventa y siete y para que de ello conste de pedimento de *Marcos Izquierdo Montenegro* Vecino de la Villa de *Villoslada* dí la presente firmada de mi nombre y sellada con el sello de mis armas que es fecha en *Madrid* a ocho de Mayo de *mill y seiscientos* y *veinte* y *ocho* Años.

Domm Yerónimo de Mata, rúbrica.
Rey de Armas.

{Lugar del sello.}

La anterior certificación hecha a un primo de Diego Izquierdo García de Olalla, nos permite pues, comprobar que descendían de Don Diego de Guipuzcoa apellidado el Izquierdo, 1°, porque las armas son iguales a las que describe Zazo; 2°, porque corresponden a individuos pertenecientes a la rama que según el mismo Zazo fundaron en tierras de Cameros. También demuestra la ascendencia esta Don Juan Izquierdo de Roças, porque en derredor del blasón lleva escrito el lema heráldico que hace alusión al lugar de su señorío, las Torres de Roças, en el Valle de Soba.

Casó Diego Izquierdo con *Elvira Ruiz*, hija de Juan Ruiz, también nacida en Villoslada. Es casi seguro que este Juan Ruiz sea el mismo Juan Ruiz de *Villoslada*, que tomado de la Historia de Gaspar García de Alarcón, cita Fernández Duro en la Historia de la conquista de las Azores, como uno de los que fueron a conquistarlas en 1583, mandando tercios con el título de *Maestro de Campo*, que era el que les correspondía en aquella época.

Tuvieron por hijo, entre otros, a *Pedro Izquierdo*, nacido en Villoslada el primero de agosto de 1568, y casado en la propia villa el 15 de enero de 1602, con *María de la Cámara*, también nacida allí, el 18 de enero de 1585. (De estos datos, así como de los que siguen, relativos a mi ascendencia directa, tengo los certificados de las partidas de nacimiento, defunción y casamiento, autorizados por el Obispado de Calahorra).

Su hijo *Francisco Izquierdo*, vino al mundo en Villoslada, el 6 de abril de 1621 y casó el 21 de mayo de 1645 con *Juana de Nájera*, perteneciente a la misma familia del Venerable Sebastián de Nájera, llamado de Villoslada, que fué Prior del Convento de San Martín de Madrid.

En uno de sus biógrafos encontramos que "la nobilísima estirpe de los Náxeras tuvo su origen en el Rey de Navarra llamado Don García de Náxera, hijo del Rey Don Sancho el Mayor. Casó este valeroso Príncipe con la Reina Doña Estefanía y tuvieron a los dos Sanchos V y VI de este

nombre, Reyes de Navarra." Entre otros muchos ilustres descendientes, cita Fray Pedro de la Asumpsión "a San Luis Rey de Francia, a Santo Domingo de Guzman, al Santo Rey San Fernando, a San Martín de la Huerta y a Don Pedro Fernández, fundador del Orden Militar del Señor Santiago, amén de otros muchos, nacidos igualmente" en Villoslada de los Cameros, que tiene su asiento en el Reyno de Castilla la Vieja y el Ducado de Náxera, famosa por su antiguedad, insigne por su vecindad y trato; podría hacerse copioso Nobiliario de sus muchas ilustrísimas familias" (3).

Don *Pedro Izquierdo* y *Nájera*, nació en Villoslada el 9 de noviembre de 1648 y casó con Doña *Catalina* González Orduña, nacida en la misma villa el 30 de octubre de 1651. Es seguro que los contrayentes debieron tener algún parentesco, pues la partida de su bautismo dice (folio 117, vuelta, del tomo séptimo del libro de bautizos citado) que fué bautizada "Catalina yja lejítima de Ju^n^ González de Orduña y de Juana de Nájera-sus abuelos paternos fueron P^o^ González y María Izquierdo."

Pedro González, de Villoslada, abuelo de Doña Catalina, fué Caballero de Santiago en 1625 y Caballerizo del Infante Cardenal; había nacido en Málaga el 7 de agosto de 1594 y era hijo del Capitán Miguel González, de Villoslada, Familiar del Santo Oficio de la Inquisición y Regidor Perpetuo de Málaga, oriundo de Villoslada, donde estaba casado con Doña Gerónima de Alderete. Los padres de este Capitán eran Pedro González y Margarita Sánchez, de Fuencaliente.

No he podido averiguar ni el lugar ni la fecha hel casamiento de Pedro Izquierdo con Catalina González, pues ni en Villoslada ni en Pedroso ha podido encontrarse el acta matrimonial. De los hijos habidos en él, *Don Juan Izquierdo González Orduña* es el continuador de la rama directa y el fundador de la familia mexicana. Nació en Villoslada el 14 de noviembre de 1676, según reza su partida de nacimiento, asentada en el folio 143 del tomo VIII del Libro de Bautizados de esa Parroquia: "En la villa de Villoslada, en la Parroquial della a beinti Uno de noviembre deste año de mill y seisctos y setenta y seis años, Yo Blas López, presbítero, cura y Veneficiado de ella Bauticé y Crismé a Juan, hijo lexítimo de Pedro Hizquierdo y de Cathalina González sus padres; Sus abuelos paternos fueron Fran^co^ Hizquierdo y Juana de Nájera, y maternos Juan González y Juana de Nájera. Fué su padrino Juan de Nájera, y nazió el contenido en catorce del dho mes y año dhos - Blas López - "

GENERACIONES MEXICANAS

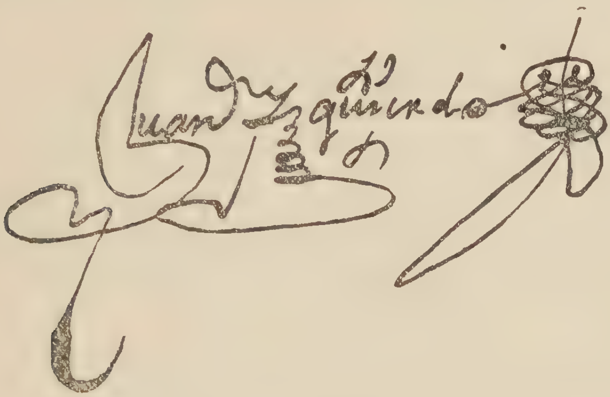
No he logrado averiguar cómo y cuando llegó a la Nueva España Don Juan Izquierdo González. Hasta los 55 años de edad, siendo Capitán, es cuando lo encontramos tomando posesión del cargo Rejidor Propietario de la Ciudad de Puebla de los Angeles. De ello da cuenta el número 4 de la *Gazeta de México* publicada por el Bachiller Arévalo Ladrón de Guevara, correspondiente al mes de diciembre de 1731, entre otras noticias de Puebla: "Los días 18 y 21 tomaron possession de Regidores de esta Ciudad, el Capitán D. Juan Antonio Izquierdo y D. Manuel Hidalgo de Veguellina" (Gazetas de México. Reproducidas por el Dr. N. León en su Bibliografía Mexicana del Siglo XVIII. México, 1903. Pág. 293).

En el tomo número 42 de los libros de cabildos de la Ciudad de Puebla, años de 1729–1732, a fojas 317, vuelta, está el acta del cabildo celebrado el día 18 de diciembre de 1731, convocado expresamente por Don Pedro de Echeverría y Orcolaga, Justicia Mayor y Teniente de Capitán General," "para entrar en possessión del empleo de Rexidor de esta Novilíssima Ciudad a Don Juan Izquierdo."

En dicho cabildo, Don Juan Izquierdo presentó un Real Título y Superior Despacho, expedido por Don Felipe V, en el que se refiere que Don Juan Izquierdo había hecho una petición ante el Virrey Don Juan de Acuña, Marqués de Casa Fuerte, en la siguiente forma:

Excelentíssimo Señor: Dn Juan Izquierdo, vno de los diputados del Comercio de la Ciud de la Puebla de los Angeles, como mejor proceda de derecho digo quen dicha Ciudad se hallan vacos varios oficios de Rexidores, pues aunque hay ocho existentes, son con el título de Interinarios...... Esto supuesto, pongo presente a V. Ex. que para que yo pueda obtener el cargo de tal Rexidor, concurren en mí las cualidades y circunstancias prevenidas por Reales disposiciones sin que haya impedimento que pueda embarazármelo, a cuia vista se ha de servir su Exa hacerme la honra de nombrarme por Rexidor del número de dicha Ciudad en propiedad, despachándoseme título en forma, pues por lo que a mí toca estoy prompto a cumplir con lo que fuere de mi obligación en la forma acostumbrada por cuia gracia ofrezco servir a su Magd, que Dios guarde, con un mil pesos que con efecto enteraré en la real Caja de esta Corte despachándoseme título o concediéndoseme la gracia sin la solemnidad de que dicho oficio salga a pregón, pues si llega a salir, en ese caso no ha de ser visto el que haya yo haya de exhiuir dhos un mil pesos y se ha de hauer como si no los hubiera ofrecido y por esto en el caso de que halla de salir a el pregón, sólo hago postrera ael tan sólo en seiscientos pesos rematándose dicho oficio por ellos con los que entonces únicamente serviré a su Magd y no con los dhos. un mil. El Motivo que tengo para la separación de estos dos casos y posturas es que no saliendo ael pregón el oficio, a costa de quatro cientos pesos más que van, a decir de los seiscientos, logro el tiempo que se havía de ocupar en las diligencias y restituirme a dicha Ciudad con la breuedad que necesito, haciéndoseme cargo del justo Interés que a su Magestad le resulta de esto, pues en tantos

años como hasta oi han corrido. no ha hauido persona que se aliente a hacer postura alguna sin embargo de estar assí ordenado y prevenido. A V. Ex[a] suplico assi mande, que es Justicia. Juro en la forma y en lo necesario, etc. Don Juan Izquierdo.



FACSIMILE No. 1

En vista del escrito, el "Fiscal de su Magestad" comisionado por el Virrey para distaminar acerca del particular, produjo su respuesta en los siguientes términos: Podrá V. Ex[a]. en virtud de sus facultades, condescender en lo que esta parte pide haciéndole merced de uno de los oficios de Rexidor de la expresada Ciudad con la calidad de vendible y renunciable y despacharle el título correspondiente enterando los un mil pesos y lo correspondiente ael Real derecho de media annata con la calidad de que ha de traer Real confirmación dentro de los cinco años de la ley a que es obligado deuajo de la pena en ella impuesta declarando para quitar toda duda ael tiempo de la possessión deuer preferir ael suplicante a todos los Rexidores Interinos que hubiere, en asiento, voz y voto, sobre que V. Ex[a]. resolverá lo que tuviere por más de Justicia que pide. México y Septiembre dose de mil setesientos y treinta y uno. Licenziado Palacios.

En virtud de lo anterior, y de haberse enterado en las Reales Cajas los pagos correspondientes, sigue diciendo Don Felipe V, en su Real Título:

"En cuya conformidad y atendiendo a hauerse ejecutado los enteros que constan de las certificaciones insertas y que en la persona de vos es expresado Don Juan Izquierdo concurren las partes de calidad y demás circunstancias necesarias para obtener el referido empleo, con acuerdo de dho mi Virrey he tenido a bien elegiros y nombraros como por el presente os elijo y nombro, por Rexidor Propietario, uno de los del número del Cauildo y Ayuntamiento de la mencionada Ciudad de la Puebla de los Angeles

para que como tal lo useis y exersais por todos los días de vuestra vida en todos los casos y cosas anexas y concernientes a dho empleo según y de la manera que lo han hecho, podido y deuido hazer los demás Rexidores que han sido y son del expresado Cauildo de dha Ciudad de la Puebla, gozando como ellos, de todas las honras, gracias, preheminencias y demás inmunidades que por Razón de al Regidor Propietario os tocan y pertenecen bien y cumplidamente sin que os falte cosa alguna de ello, teniendo el lugar, voz y voto que os corresponde, prefiriendo en este particular a los Rexidores que hubiere interinos en el expresado Cauildo por estar assí declarado por dho mi Virrey para obviar toda duda al tiempo de la possessión de este empleo sin poner en ello embarazo ni réplica para su uso y exersicio y en caso de que se pon ga algún impedimento, Yo desde luego os doi por admitido y receuido para que libremente podais seruirlo, ... etc., etc."

La preferencia que establecía el Real Título, por cierto justamente, puesto que todos los demás regidores eran interinos, fué considerada por éstos como contraria a sus intereses, lo que motivó que Don Jorge Nájera Enciso dirijiera al Virrey, Marqués de Casa Fuerte, el siguiente memorial: "Exsmo. Señor: Don Juan Izquierdo Rexidor Propietario del Cauildo de la Ciudad de la Puebla de los Angeles con la mayor veneración parezco ante V. Exs^{a}. y so las protestas de Indemnidad de todos los recursos y acciones de su parte, Digo que en atención a hauer servido a su Magestad con la cantidad de vn mill pesos, etc. . . . . y hauiéndoseme librado Real Título en forma, ocurriendo a aprehender possessión del referido empleo, se le impugna lo resuelto por dicho Real Título en aquel Cauildo en quanto a la referida preferencia a dhos Rexidores Interinarios a quién ha convocado fuertemente el Justicia Mayor de aquella Ciudad sin otro motivo que el de perjudicarme por sus fines particulares y porque assí dicho Justicia Mayor como los Rexidores se hallan incursos en total inouediencia de lo resuelto por su Magd en dho Real Título se ha de seruir la Justificación de V. Ex^{a}., precediendo la condigna corrección y pena que fuere de su superior agrado, mandar se lleue a puro y deuido efecto lo resuelto por dho Real Título agrauando las penas de dho Justicia Mayor y Rexidores para en el caso de alguna o la más leue omisión para su éxito. . . . .

Los Regidores, por su parte, presentaron otro memorial en el que expresaban "hallarse conuenidos y ajustados en que al dicho Izquierdo se le dé el último lugar después de los que oy se hallan apossessionados deuajo de las protestas de quedarle al enunciado Don Juan Izquierdo sus derechos a saluo para usar de ellos donde y quando le conuenga." . . . . El Fiscal informó al Virrey diciendo que "sin embargo de que por los Instrumentos

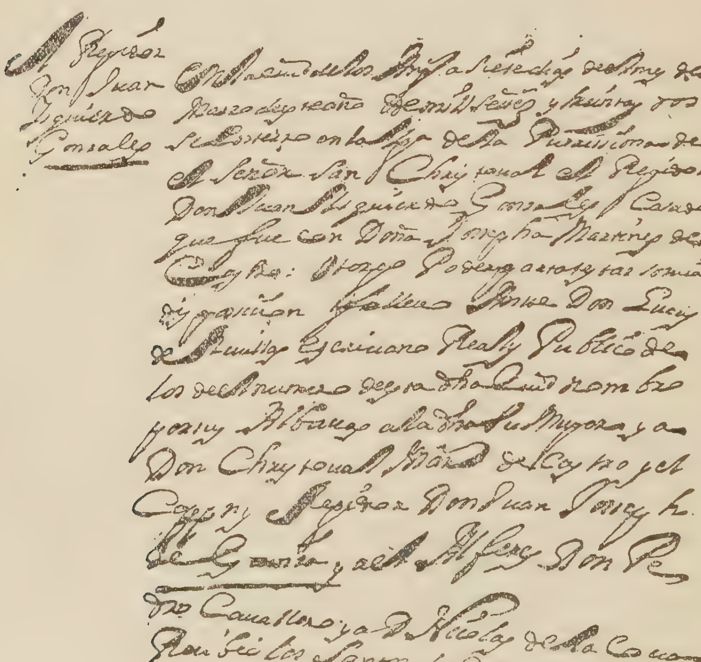
que vnos y otros han presentado se canoniza de justa y legal la resolución de V. Ex[a]. y que su Magestad quiere que se guarde lo mandado en la expresada ley en quanto a la preferencia y que en su conformidad se deuía precisar a que diese possessión al dho Don Juan Izquierdo con preferencia a todos los Interinos, imponiéndoles graues penas para su cumplimiento por ser frívola y sin fundamento su oposición, sin admitirles por esta causa renunciación y dejación de sus oficios y que en caso de intentarla o hazerla, se les deua apremiar a que prosiguiesen exersitándolos; no obstante, para obviar enquentros, disenciones y sin perjuicio de los derechos fiscales y del que compete ael referido Don Juan Izquierdo, podrá V. Ex[a]., siendo seruido, condescender por ahora a dho conuenio y mandar librar el despacho correspondiente y que los referidos oficios de Rexidores Interinarios se pregonen para ver si ay postores y se saquen a la almoneda." A cuyo parecer ajustó el Virrey su decisión, con el carácter de provisional.

Fué entonces cuando Don Pedro de Echeverría y Orcolaga convocó a Cauildo para el 18 de diciembre de 1731. Reunido que fué, los Rexidores emitieron sus pareceres y, "regulados los votos, de mandato de dho Señor Justicia Mayor, se guardó lo uotado por la mayor parte en cuya conformidad la dha Nouilíssima Ciudad tomó en sus manos dho Real Título, lo besó y puso sobre su cabeza y dixo que lo obedecía y obedeció con el respeto deuido a carta y provisión de nuestro Rey y Señor natural que Dios guarde, y que no puede dexar de reclamar ni pasar en silencio lo siniestro del informe que se hizo por Don Juan Izquierdo en que se asienta auer inducido a los Señores Capitulares interesados en este negocio el Señor Justicia Mayor Presidente de este Cauildo, siendo assí que a su solicitud se deuió la mayor quietud que pudiera desearse para que no resultaran enconos ni malas voluntades en defensa del derecho y lustre de los individuos contra quienes resultaba la preferencia en cuya diligencia motu propio se juntaron los comprehendidos de cuya acción resultaron los buenos oficios que experimentaron después de hauer librado llanamente el citatorio acostumbrado y respecto a que assí mismo se silenció el goze de preferencia a propietario que ha gozado el Señor Don Nicolás de Castro sin contradicción alguna y no pudiendo preferir a dicho Don Juan Izquierdo a Don Miguel Cerón sin causarle despojo, se ocurra por parte de dhos regidores al Real y Supremo Consejo de las Indias a representar todo lo que ocurre, a cuyo efecto se les dén los testimonios que pidieren y de lo que contiene el testimonio que por el Señor Don Manual Santerbás se ha trahído de lo que se practica en la Ciudad de México entre los Regidores propietarios e Interinos sobre el lugar y asiento de que gozan y a dho Don Juan Izquierdo se entre en possessión de su empleo de Rexidor a cuyo efecto, dádose Razón por Joseph de

Sumaia, Portero de Cauildo de que el sussodicho esperaba en los corredores de Palacio, le salieron a receuir algunos de los Señores Capitulares. En aceptación de dho empleo se le reciuió Juramento por mí el Esscrivano, que hizo por Dios Nuestro Señor y la Señal de la Sancta Cruz según derecho, so cargo del qual prometió usar bien y fielmente de dicho oficio de Rexidor como deue y es obligado, etc., etc., ... a cuya obsolución el dicho Juan Izquierdo dijo Sí Juro y Amén. Y esto fecho, se le dió el asiento que le corresponde, el último después del Señor Rexidor más moderno." (Tomado del Archivo Municipal).

En el cabildo del 2 de enero de 1732, encontramos a fojas 339 del libro de cauildos citado, "que la Nobilíssima Ciudad dixo que nombraua y nombró por Obrero Mayor al referido Don Juan Izquierdo a quién encarga el cuidado de las cañerías y el aliño de las casas de sus propios y otras cossas necesarias, para lo qual le daua comissión en bastante forma y el poder que de derecho se requiere y sea necesario y por el trabajo y ocupación que en ello ha de tener, le asignaba y asignó cien pesos de salarios, pagados de sus propios como es costumbre."

Sin embargo, no pudo Don Juan Izquierdo llevar a cabo su obra, ni llegó a saber la resolución del Consejo de Indias, porque falleció el día 4 de


Al Regidor Don Juan Izquierdo Gonzalez

[illegible] Regidor Don Juan Izquierdo Gonzalez [illegible] Casado que fue con Doña Josepha Martinez de Castro: [illegible] Escribano Real y Publico [illegible] Don Christoval Martinez de Castro [illegible] Regidor Don Juan [illegible] y al Alferez Don Pedro Cavallero y a D. Nicolas [illegible]

Facsimile No. 2

marzo de ese año, según puede verse en su partida de defunción, que logré encontrar en el archivo del Sagrario de Puebla y que en facsímile va a continuación.

He recorrido minuciosamente el templo de San Cristóbal de Puebla, en donde la partida anterior declara que fué enterrado Don Juan, sin encontrar huella alguna de su tumba. El piso ha sido renovado, quizá no una sino varias veces en el espacio de tiempo transcurrido hasta la fecha, de cerca de doscientos años, y es seguro que por eso la lápida también ha desaparecido.

En la *Gazeta de México* número 52, correspondiente al mes de marzo de 1732, entre las noticias de Puebla de los Angeles, sigue la de que "el día 4 murió el Capitán Don Juan Antonio Izquierdo, Rexidor de esta Ciudad y Diputado de Reales Alcabalas. (Gazeta de México con licencia del Excmo. Señor Virrey. En México, en la Imprenta Real del Superior Gouierno, de los Herederos de la Viuda de Miguel de Rivera Calderón, en el Empedradillo).

A fojas 387 del tomo citado del archivo muncipal de Puebla, el Procurador Mayor informa de haber revisado las cuentas de Don Juan Izquierdo y dice: "que las tiene reconocidas con los instrumentos que se han presentado de su comprouasión y dellos consta que hauiendo sido electo Obrero Mayor de esta Nouilíssima Ciudad el Señor Don Juan Izquierdo su Capitular ya difunto, exersió dicho empleo el tiempo que uiuió desde principios de este año en que fabricó y reforzó las presas del río que llaman de San Francisco, por donde pas sa la cañería del agua que uiene a esta dicha Ciudad y juntamente hizo otras obras necesarias al bien público, en que gastó la cantidad de quinientos quarenta pessos quatro reales y medio como parece de los reciuos que ha presentado el Cap^{n} D^{n} Xpoual Martínez de Castro, Aluasea de dho Señor difunto."

El Capitán y Regidor Perpetuo de la Puebla de los Angeles, Don Juan Izquierdo González, en fecha que no he podido averiguar, casó con *Doña Josefa Martínez de Castro*, cuya genealogía era como sigue:

General Gabriel Guadalajara — María Ana Caballero

Pedro Guadalajara — Maria Ana de Sagasti

Francisco Guadalajara — Tomasa Martínez

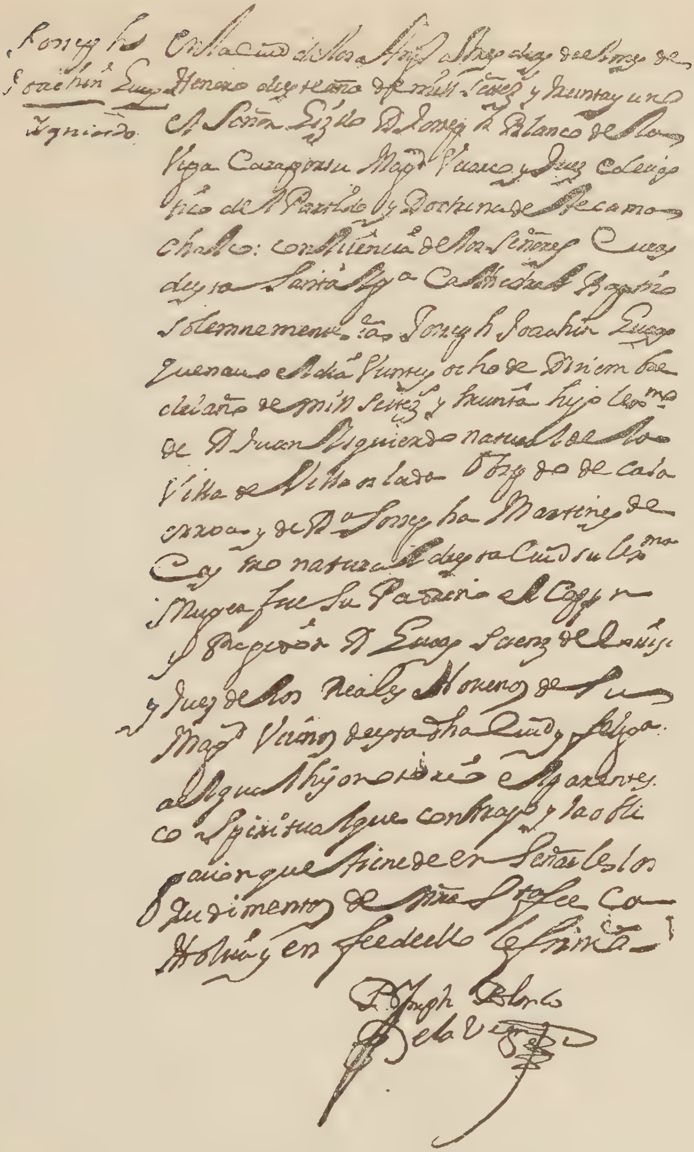
Gertrudis Guadalajara — Cristobal Martínez de Castro

Josefa Martínez de Castro

Ignoro sus fechas de nacimiento y de muerte y sólo he podido averiguar que nació en Puebla y que después de la muerte de su esposo casó en segundas nupcias con el Capitán Don Nicolás Gómez, de Rucoba, también Regidor de la Ciudad de los Angeles, que falleció el 2 de enero de 1755, dejándola viuda, y que está enterrado en el templo de Santo Domingo, de Puebla.

Del matrimonio de Don Juan Izquierdo y Doña Josefa, nació *Don Joseph Joachin Izquierdo*, el 28 de diciembre de 1730, siendo bautizado el 3 de enero del año siguiente, en el Sagrario de la Catedral Angelopolitana, según consta en su acta de bautismo, puesta a continuación (Archivo Parroquial del Sagrario de Puebla; libro de bautismos número 31; años de 1729–1730, a fojas 245). En ella se encuentra consignado el lugar de orígen de Don Juan Izquierdo, su padre, dato que me sirvió de punto de partida para investigar lo relativo a las generaciones españolas.

Don Joseph Joachin también fué Capitán y Rejidor Perpetuo de la Ciudad de Puebla. Rebuscando en el archivo municipal de la Ciudad, encontré que ingresó como Rejidor el 26 de junio de 1755. En el cabildo de ese día se vió su Real Título, expedido por Fernando VI, en el cual se refiere cómo, Don Nicolás Gómez de Rucoba que según vimos, había casado en segundas nupcias con Doña Josefa Martínez de Castro, madre de Don Joseph Joachín, había "renunciado el oficio de Rejidor de la Nobilíssima Ciudad, en primer lugar en Don Joseph Joachín; en segundo, en Don Joseph Izquierdo, vecino y Labrador de la Provincia de Atlixco, y en tercero en Don Juan Enciso de Thexada." Consta después la siguiente certificación: "Manuel del Castillo, Escriuano del Rey Nuestro Señor que Dios guarde, Público, Propietario y uno de los del número de esta muy noble y muy leal Ciudad de los Angeles, Notario Receptor de los Juzgados eclesiásticos deeste Obispado y del Sancto Oficio de la Inquisición de este Reino. Certifico y doy fee en testimonio de verdad que oy día de la fecha, cosa que serán las quatro y media de la tarde, estando en las casas que fueron de la morada del Cap^{n} D^{n} Nicolás Gómez de Rucoba Rejidor deesta Nma. Ciudad, veo en la Sala principal de ella el cuerpo del citado Dn. Nicolás amortajado con áuito de nuestro Seraphico Padre Señor San Fran^{co}, que, se halla al parecer muerto y sin espíritu de vida, al qual conocí, traté y comuniqué uiuiendo y para que conste donde convenga, de pedimento de Dn. Joseph Joachin Izquierdo González doy la presente en la referida ciudad de los Angeles a treinta y un días del mes de Diciembre de mil setecientos sinquenta y quatro anos, ... hago mi signo en testimonio de verdad. Manuel del Castillo Escriuano Real y Publico."


Joseph Joachin Enriqz Izquierdo.

En la Ciudad de los Angs a diez y ocho dias del mes de
Henero de este año de mill setez. y treinta y uno
el Señor Lizdo D. Joseph de Blanco de la
Vega Cura por su Magd Vicario y Juez Colesias-
tico del Partido y Doctrina de Tecamo-
chalco: con licencia de los Señores Jueces
de esta Santa Ygla Cathedral Bauptizo
solemnemente a Joseph Joachin Enriqz
que nacio a diez y ocho de Diciembre
del año de mill setez. y treinta hijo legmo
de D. Juan Izquierdo natural de la
Villa de Villarrubia Obispado de Cala-
horra y de Da Josepha Martinez de
Coy natural de esta Ciud su legma
Muger fue su Padrino el Cappn
Regidor D. Enriqz Saenz de Aniz
y Juez de los Reales Novenos de su
Magd Vecinos de esta dha Ciud y se le ad-
virtio el parentesco
Spiritual que contrajo y la obli-
gacion que tiene de enseñarle los
rudimentos de Nra Sta fee Ca-
tholica y en fee de ello lo firme.

D. Joseph de Blanco de la Vega

Facsimile No. 3

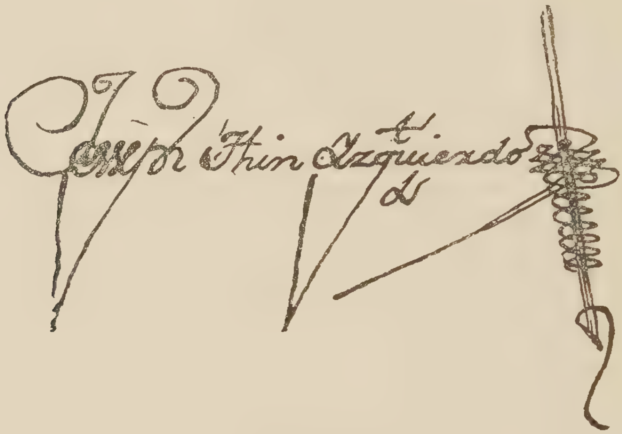
LLenos los demás requisitos y formalidades necesarias, que aquí es imposible enumerar; evaluado debidamente el oficio renunciado, por varios peritos; enterados en la Real Caja los pagos relativos y comprobado todo ello debidamente, sigue diciendo Don Fernando VI en su Real Título: "En cuya conformidad y atendiendo a que en la persona de Vos Dn Joseph Joachín Izquierdo González Martínez de Castro concurren las partes de calidad, idoneidad, suficiencia y demás circunstancias, con acuerdo del repetido mi Virrey, Conde de Reuillagigedo, he tenido a bien elegiros y nombraros como por el presente os elijo, proueo y nombro, por Rejidor, uno de los del número del Cauildo de la Ciudad de la Puebla de los Angeles para que como tal Rejidor propietario useis y exersais este empleo en todos los casos y cosas a él anexas, ... etc., etc."

El Capitán y Rejidor Don Joseph Enciso de Thexada, dijo: "que obedeciendo como obedece con el respeto y veneración deuida al Superior mandato de que se ponga en posesión del Rejimiento que se haya despachado Don Joachin Izquierdo, pero en quanto a su cumplimiento haze presente a esta Nma. Ciudad berzarse en dha posesión el interés Real a cuio augmento todos estamos obligados por estar hecha la renuncia de dho. Rejimiento en virtud de la qual se le libraron despachos en sujeto menor de edad y no se le hubieran librado con noticia de serlo, pues para que fuesse válida necesitaua la gracia y expresa concesión de S. Magd., que Dios guarde, en la que a Don Nicolás Gómez de Rucoba le concediesse facultad de poder executar las renunciaciones del oficio de Rejidor que obtenía en sujetos menores de edad . . . . por lo que procurando el mejor y más seguro acierto en el asumpto y su conciencia, es su voto se llame a este cauildo el abogado de esta Novma. Ciudad para que en inteligencia y con prospecto a los despachos presentados por el pretendiente y las leyes que tratan del asumpto y el interés Real, diga lo que se deua ejecutar porque las leyes lo tendrán determinado a beneficio de su Magestad sin perjuicio de sus vasallos. Y en su vista dha Nouilíssima Ciudad mandó llamar al Licdo. Don Joachin María Infante de Zetina Abogado de la Real Audiencia de México y de esta Nma. y auiendo uenido y entrado en la Sala Capitular se le hizo sauer el uoto antecedente y lo decisiuo de dho Real Título. Expuso su dictamen en papel separado cuio thenor es como sigue: "el Asesor expuso lo siguiente, que por la ley Real décima del título veinte de la Recapitulación de Indias está preuenido que no se hagan renunciaciones de oficios en personas que sean menores de edad, pena de perdimiento de los oficios y de no ser admitidas. Y que los exmos Señores Virreyes no puedan dispensar en tales cassos, aun á título de compassión. Pero que ael mismo tiempo se hace cargo de que la notoria Literatura del Señor Fiscal tuvo muy presente como siempre esta ley Real;

y que su Señoría no opuso a este defecto, o porque no le constaría ser punto de hecho; o porque según se informa y se asienta en este cauildo, el prouisto pasa de ueinticuatro años y seis meses, lo que junto con la hauilidad y partes del prouisto prestarían motiuo bastante para disimular en el corto tiempo que le falta para completar la edad; y que a esto se añade que en el mismo título se expresa la claúsula de que no se le ponga ningún defecto; y que si de hecho se le opusiere, por el mismo caso, se manda apossesionar; con cuios fundamentos concurre también la exequibilidad que piden estos Reales Rescriptos particularmente en el caso presente; en que media la Pública expectación, pues la Ciudad y República convidada para la possessión y aún la pleue, a quién se ha trascendido la noticia, están en la expectación, de que resultaría desairado el Real Rescripto, los poderosos respetos que en él se ueneran y las circunstancias que uan prenotadas, esto mediante es de dictamen que sin perjuicio de lo que por la Soueranía de su Exa. se determinare y de lo que por la notoria justificación del Señor Fiscal se pidiere con noticia del impedimento por falta de edad, se le dé al citado Don Joseph la posesión con arreglamiento al Real Título y que sobre el impedimento opuesto por defecto de la edad se consulte a la Soueranía de su Exa para que determine como siempre lo mejor, . . . etc." "Y por la Nov^a^ Ciúdad oydo el parecer antecedente dijo que conformándose como dha Nouilíssima se conforma con él, acordaua y acordó se haga en todo como por dho Asesor se consultó y en su inteligencia mandaua y dha Nov^a^ mandó a Dn Fran^co^ Valentín Ordóñez sustituto del Portero de Cauildo pasase a las casas de hauitación y morada del dho Don Joseph Joachin Izquierdo y le diesse razón como esta Nov^a^ le estaua aguardando, lo que executó dho sustituo de Portero de Cauildo y hauiendo uuelto dió noticia a dha Nov^a^ que el referido Don Joseph Joachin se hallaua en los corredores de este Palacio y le salieron a receuir algunos de los Señores Capitulares y hauiendo entrado en dha Sala Capitular por ante mí el Escriuano juró por Dios nuestro Señor y la Señal de la Sancta Cruz en forma de derecho, de vsar bien y fielmente el empleo de Rejidor, etc. etc. . . ." (Archivo Municipal, loc. cit.).

El día siete de agosto del mismo año, presento ante el cabildo un Superior Despacho de Don Juan Francisco de Güemez y Horcasitas, Conde de Reuillagigedo, Gentil hombre de la Cámara de Su Magestad, con entrada, Tenien te General de sus Reales exérsitos, Virrey Gouernador y Capitan General de esta Nueva España y Presidente de la Real Audiencia de ella, etc., por el cual, atendiendo a que Don José Joaquín había comprobado con su partida de bautismo, tener veinticuatro años y cerca de siete meses, fundándose en que la ley 17, título tercero, del libro séptimo de la Recapitu-

lación de Castilla sólo exigía la edad de veinte años para obtener el oficio de Rejidor, declaraba "por uálida la renuncia hecha por Don Nicolás Gómez de Rucoba en el referido Don José Joaquín y en su consecuencia, por subsistente la posesión que se le había dado del oficio de tal Rejidor del número de la cuidad de la Puebla por su Cauildo y Ayuntamiento a los ueintiseis de junio próximo pasado de este año."



Facsimile No. 4

Anticipándose a la llegada del nuevo Virrey, en el cabildo del 23 de julio de ese mismo año de 1755, "la Nov^a Ciudad dijo que nombraua y nombró a los Capitanes y Rexidores Don Juan Joachin Micieses Altamirano y Don Joseph Joachin Izquierdo para que fueran al Pueblo de Thepellahualco a Receuir al Ex^mo Señor Virrey, próximo a conducirse a esta Nueua España." En la descripción del viaje de la Marquesa de las Amarillas, hecha en verso por Don Antonio Joaquín de Rivadeneyra Barrientos, (reimpresa con notas de Don Manuel Romero de Terreros y Vinent, Marqués de San Francisco, en los Anales del Museo Nacional, tomo V, núm. 4, 1914, pág. 235), se refiere que el encuentro tuvo lugar el 21 de octubre, según rezan, los siguientes versos, ramplones y de mal gusto como todos los de la obra:

A Perote venimos,
distante quatro leguas, donde hicimos
mansión la noche, siendo la jornada
a Población nombrada
Thepeyahualco la del día veinte y uno.
Allí nos alcanzó uno
de los dos Secretarios de Gouierno,

y con las muestras de un amor paterno,
Augustín recibió los Diputados,
que llegaron embiados,
de la Villa y la Puebla.

La ciudad se aprestaba a recibir a sus huéspedes y los comisionados para su recibimiento, con el fín de disponer los alojamientos, presentaron la siguiente curiosa relación de la familia que traía el Maqués de la Amarillas, que reproduzco por lo interesante y pintoresca que la encuentro: (fojas 149, vuelta, del tomo citado): "Razon de la familia que trae el Señor Virrey. = La Señora marquesa Dña Luisa de Ahumada uiene en sinta = Dn Augustín de Ahumada y Villalón su hijo de ueinte y ocho meses con grado de Coronel y Capn de la Compañía de Cauallos de Palacio = Don Manuel Baamont, etc. etc. = Damas y criados, ocho = Pajes y Marmitones, más de sesenta = confesor, el padre Fray Pedro Moreno, dominico. = Trae su excelencia un ajuar muy exoruitante."

Las comisiones principales que desempeñó Don Joseph Joachin Izquierdo, fueron: comisario de tierras en el año de 1756; diputado, veedor de carnicerías, patrón de fiestas y procurador de pobres, en los siguientes.

En el cabildo del 15 de junio de 1757, presentó un segundo real título de confirmación de su Regimiento, expedido por Don Fernando VI, y después, estando para llegar el Nuevo Virrey Dn. Francisco Cajigal de la Vega, fué nombrado para darle la bienvenida, en Tepeyahualco, pero no llegó a desempeñar la comisión por haberse excusado por motivos de enfermedad.

En 1766, presentó a Don Joaquín de Monserrat, Marqués de Cruillas, la "renuncia de su cargo de Rexidor, por motiuo de hallarse hauitualmente enfermo de hauer experimentado nosiuo el temperamento de aquella Ciudad. Se hauía retirado a su hazienda de labor asistiendo en ella la mayor parte del año por recuperar assí su salud con el natural deseo de conservarla; que este impedimento físico de asistir en dha Ciudad le era consequentemente de seruir el empleo de Rexidor dexándole en el desconsuelo a que tal vez por su falta experimentase el Público algún perjuicio y para euitarlo hauía deliberado separarse enteramente de él, y por lograrlo con utilidad de la Real Hazienda, en seruicio y obsequio de su Magestad, desde luego lo renunciaba a su fabor en mis manos para que se vendiesse a su beneficio con la calidad de gozar de los honores que de ninguna manera renunciaba."

. . . El Virrey, en su vista y teniendo en cuenta la respuesta del Fiscal, de fecha 12 de noviembre de ese año, decía: "teniendo presente que la renuncia que a favor de su Magestad hace Don Joseph Joachin Izquierdo es sin duda a beneficio de su Real Auer, etc. . . . . no ai inconveniente en que yo le conceda la renuncia atento el particular seruisio

referido, entendiéndo se de los priuilegios y excempciones que no estén adictos al actual exersicio y de aquellas que sin agrauio o perjuizio de tercero sólo siruan para mantener el decoro, esplendor y estimación deuida a un sujeto que ha sido miembro de Aquel Ayuantamiento y se aparta de él por su voluntaria renuncia." . . . .

El Capitán y Rejidor Don Joseph Joachin Izquierdo, casó con Doña *María Gertrudis Yáñez de Vera*, hija de Don Ignacio Yáñez de Vera y de Doña Josefa Camino Frías. No he llegado a saber las fechas de nacimiento y defunción de ella, ni la del matrimonio.

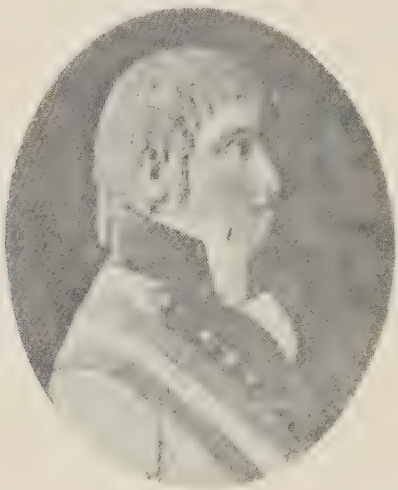
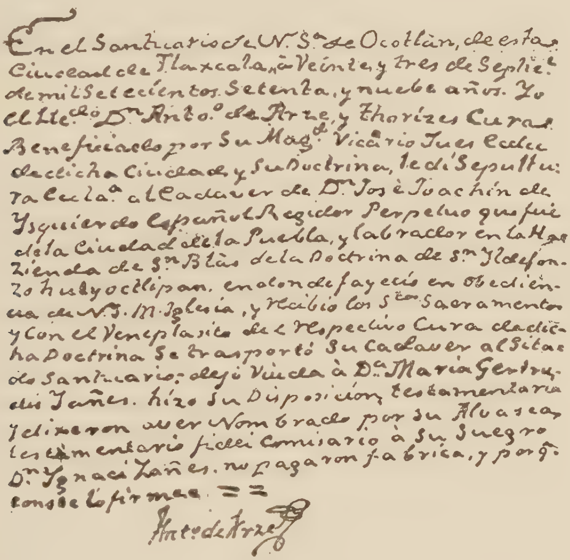


Fig. 3. El Capitan y Regidor de la Puebla de los Angeles Don Joseph Joachin Izquierdo

Murió Don José Joaquín en su hacienda de San Blas (Estado de Tlaxcala), el 20 de septiembre de 1779, dejando viuda a su esposa. Su cuerpo fué llevado al Santuario de Ocotlán, a extramuros de Tlaxcala, donde fué inhumado. En un libro de entierros existente en el convento de San Francisco de la cuidad de Tlaxcala, consta la partida siguiente:

La familia conserva un retrato de Don Joseph Joachín, que mi distinguido amigo el Marqués de San Francisco describe así: "El retrato es en cera, probablmente de los que ejecutaba Francisco Rodríguez a fines del siglo XVIII y principios del XIX. Como casi todos sus congéneres, el personaje está representado de perfil y colorido. El cabello, gris, está peinado a la manera de la época en que empezaron a desecharse las pelucas.

Viste uniforme militar azul pálido con vueltas negras y ribetes rojos; la chupa es encarnada; y ostenta banda azul y blanca, aparentemente de Carlos III, pero el azul es mucho más oscuro que el que corresponde a esta Orden. Como los retratos en cera no se generalizaron en México sino hasta después de 1779, este retrato debe haber sido hecho después de la muerte del Señor Izquierdo. La caja ovalada de plata que lo contiene está surmontada por una corona del mismo metal, que evidentemente no le pertenece."


En el Santuario de N. Sra de Ocotlán, de esta
Ciudad de Tlaxcala, á Veinte y tres de Septiem
de mil Setecientos Setenta, y nuebe años. Yo
el Lic.do D.n Anto.o de Arze, y Thorizes Cura
Beneficiado por Su Mag.d Vicario Jues Eclec
de dicha Ciudad, y Su Doctrina, le di Sepultu:
ra Eccla.a al Cadaver de D.n José Joachin de
Ysquierdo Español Regidor Perpetuo que fuè
de la Ciudad de la Puebla, y labrador en la Ha
zienda de S.n Blas de la Doctrina de S.n Ildefon.
zo hueyotlipan. en donde fallecio en Obedien
cia de N. S. M. Iglesia, y recibio los S.tos Sacramentos
y Con el Veneplasito del respectivo Cura de dicha
ha Doctrina Se trasportó Su Cadaver al Sitio
de Santuario: dejó Viuda à D.a Maria Gertru
dis Yañes. hizo Su Disposición testamentaria
y dixeron aver Nombrado por Su Albasea
testamentario fidei Comisario à Su Suegro
D.n Ygnacio Yañes. no pagaron fabrica, y porq.
conste lo firme. ==
Anto. de Arze

FACSIMILE No. 5

Aunque no he podido saber qué uniforme es el que lleva y tampoco han podido reconocerlo diferentes historiadores, amigos míos, me parece muy probable que se trate del del Regimiento del Comercio de Puebla que hallo descrito en el *Calendario Manual* y *guía* de *forasteros para el año del Señor* de 1787, dispuesto por Zúñiga y Ontiveros. Consta allí que "el Regimiento del Comercio de Puebla, está formado de un batallón: Fué creado en 1740. Está aprobado por S. M. bajo las mismas reglas y Priuilegios que el de México. Su uniforme: casaca y calzón *azul*, chupa y vuelta *encarnada*, botón *blanco*, y los oficiales galón de plata al canto de casaca y chupa."

De los siete hijos de Don Joseph Joachín y de Doña María Gertrudis, que pueden verse en el árbol, Don *José Ignacio Mariano Izquierdo*, es el continuador de mi rama directa. Nació en la hacienda de San Blas el 4 de

julio de 1769 y casó, en fecha que ignoro, con Doña *Mariana de Hogal.* Hasta el presente no me ha sido dado averiguar la fecha y el lugar de su muerte, así como los de su esposa.

Don *Joaquín María de Jesús Izquierdo*, su hijo, nació en San Blas, el 16 de mayo de 1802 y fué hermano de otros nueve que aparecen en el árbol. Casó en primeras nupcias con Doña *Rosalía Bernal*, madre de mi abuelo, y en segundas con Doña Cayetana Hogal, de la cual resultó una pequeña rama que aparece en el árbol, ya extinguida. Su esposa murió el 7 de junio de 1844, y él, cinco años más tarde, el 3 de abril, jueves santo de 1849.

De su unión, nació el señor mi abuelo, Don *Manuel Izquierdo* y *Bernal* en 1839, y sus hermanas Dolores (1835), Soledad (1837) y Mariana (1838), priora, la primera de ellas, de las monjas inesas de Puebla.

Don Manuel Izquierdo murió en su hacienda de San Blas, el 11 de julio de 1889, y su esposa, Doña *Trinidad del Pozo*, en Puebla, el 11 de julio de 1898. En su unión, tuvieron por hijos, a Don Carlos María Izquierdo, actual propietario de la Hacienda de San Blas, la centenaria propiedad de la familia, nacido en 1859; a Doña Isabel, nacida en 1860; a Don Joaquín Pelayo, mi padre, nacido en 1865; y a Doña María y Don Antonio, nacidos en 1867 y 1873, respectivamente.

Don *Joaquín Pelayo Izquierdo*, mi padre, nació en Puebla, el 26 de ju nio de 1865, y casó en la misma ciudad, el 27 de abril de 1892, con Doña *María Raudón Asúnsolo*, nacida en Aguascalientes el 4 de diciembre de 1866, hija de Don Ignacio Raudón, coronel que fué del Ejército Mexicano, condecorado con la Cruz de la Angostura por haber combatido en esa acción contra el invasor yankee, y caballero de la Imperial Orden de Guadalupe, y de Doña Emilia Asúnsolo.

Don Joaquín Izquierdo fué Rejidor de la Cuidad de Puebla, casi a los doscientos años de que lo habían sido sus antecesores. Pero como los tiempos eran completamente diferentes, lo fué por elección que por mucho tiempo será entre nosotros la única que verdaderamente fué democrática, el 11 de diciembre de 1911. Ingresó como rejidor propietario el 30 de marzo del año siguiente, de 1912, ancargándose de la sección de policía, y por varios dias desempeñó interinemante la presidencia municipal, en octubre y noviembre del propio año. El 12 de noviembre se hizo cargo de la segunda sección de hacienda, y el 31 de marzo de 1913, le era concedida una licencia ilimitada para separarse de la corporación municipal. Murió el 12 de agosto de 1913.

José Joaquín Izquierdo, nacido en Puebla el 8 de mayo de 1893, hizo sus estudios de médico-cirujano en el Colegio del Estado de Puebla y sustentó su examen profesional los días 4, 5 y 8 de enero de 1917. Al recibir su

título, vino a ser el primer profesionista habido en la familia mexicana. Es miembro de la Sociedad Científica "Antonio Alzate," Jefe de Trabajos prácticos de Fisiología y Biología en la Escuela Nacional de Medicina, Socio titular de la Academia Nacional de Medicina y fundador de la Sociedad Mexicana de Biología, etc.

THE ONEIDA COMMUNITY EXPERIMENT IN STIRPICULTURE

HILDA HERRICK NOYES, M.D., AND GEORGE WALLINGFORD NOYES, A.B.

The institution afterwards known as the Oneida Community was founded by John Humphrey Noyes at Putney, Vermont, in 1841. In 1848 under pressure of persecution the Community removed to Oneida, New York, which at that time was a frontier settlement. In its new location the Community grew and prospered until January 1, 1881, when, for reasons which need not here be detailed, it was re-organized as a joint-stock company. Since that date the joint-stock successor of the Community has carried on its business with extraordinary success, its net assets having increased from about $550,000 in 1881 to nearly $7,000,000 at the present time.

Noyes first published his views regarding human "stirpiculture," as he called it, in the "First Annual Report of the Oneida Community" in February 1849. He says:

> We are not opposed to procreation. But we are opposed to involuntary procreation. We are opposed to excessive and, of course, oppressive procreation, which is almost universal. We are opposed to random procreation, which is unavoidable in the marriage system. But we are in favor of intelligent, well-ordered procreation. We believe the time will come when scientific combination will be applied to human generation as freely and successfully as it is to that of other animals.

For twenty-seven years after its foundation the Oneida Community was engaged in working out the immediate problems of its new order of society, and could not undertake an experiment in scientific propagation. But in 1868 it found itself in a situation favorable for such an experiment in the following respects:

1. A social system based on their religion, called "complex marriage," which, under stringent regulations and circumscribed by the limits and approval of the Community, permitted the requisite flexibility in mating.

2. Sufficient income. From 1841 until 1855 expenses exceeded income. After 1855 income exceeded expenses, and during the period 1868–1872 the net income above all expenses averaged more than $47,000 per year.

3. Sufficient number of members to admit a considerable degree of selection. The membership during the eleven years of the stirpicultural experiment ranged from 271 to 306, with a slight excess of women over men.

4. Capable leaders. Noyes himself was a graduate of Dartmouth College, had studied theology at Andover and Yale, and his management of the Community during twenty-seven years had fully demonstrated his unusual ability. He was surrounded by a cabinet of men and women (among them a number of college graduates), who had shown the qualities of leadership in positions of high responsibility.

5. Confidence on the part of the members in their leaders and in the stability of the Community. The members were practically unanimous in believing that Noyes and his subordinate leaders were inspired and that the Community was the earthly representative of the Kingdom of God. Without this superlative confidence they would not have been willing to engage in such an experiment.

6. A method of subjective, healthful, reasonably effectual birth-control called "male continence," discovered by Noyes in 1844, which did not exclude from sexual communion those judged unfit to take part in the stirpicultural experiment.

7. A high degree of passional control due to the fact that discipline and effort had from the beginning been constantly directed toward perfection of character. In the early days no little trouble had been caused by jealousy and exclusiveness, but by 1868 these anti-Communistic traits had been so far conquered that altruism deemed impossible in ordinary society was commonplace in the Community.

8. Extraordinary religious devotion. This characteristic made a large majority of the Community members fervently desirous not alone negatively to avoid selfishness, but positively to engage with all their powers in any enterprise which they thought in the interest of the Kingdom of God. Such pre-eminently was the enterprise of human redemption by "combining regeneration with scientific generation."

While the Community did not pretend to unusual knowledge of stirpiculture, the leaders nevertheless devoted much study to the literature of the subject, especially the works of Charles Darwin and Francis Galton. Noyes embodied the results of his studies in an article entitled "Scientific Propagation," which was published in *The Modern Thinker*, August 1870, and later in pamphlet form.

Early in 1869 the young men and women of the Community made the following declarations:

Statement addressed to J. H. Noyes by young men

The undersigned desire you may feel that we most heartily sympathize with your purposes in regard to scientific propagation, and offer ourselves to be used in forming any combinations that may seem to you desirable. We claim no rights. We ask no privileges. We desire to be servants of the truth. With a prayer that the grace of God will help us in this resolution, we are your true soldiers,

(Signed by 38 young men.)

Resolutions of young women

1. That we do not belong to *ourselves* in any respect, but that we *do* belong first to *God*, and second to Mr. Noyes as God's true representative.

2. That we have no rights or personal feelings in regard to child-bearing which shall in the least degree oppose or embarrass him in his choice of scientific combinations.

3. That we will put aside all envy, childishness and self-seeking, and rejoice with those who are chosen candidates; that we will, if necessary, become martyrs to science, and cheerfully resign all desire to become mothers, if for any reason Mr. Noyes deem us unfit material for propagation. Above all, we offer ourselves "living sacrifices" to God and true Communism.

(Signed by 53 young women.)

The experiment which followed these declarations occupied the years 1868–1879 inclusive. About 100 men and women took part, of whom 81 became parents. During the eleven years 58 living children were born, and there were 4 still-births. A precise appraisal of the factors entering into the experiment and of its outcome must be the work of scientific specialists, preferably those wholly unconnected with the experiment itself. The present paper attempts only a brief, tentative account.

The Oneida Community was a product of successive unconscious group selections. To go no further back than the English Puritans four such selections can be distinguished:

1. The New England pioneers were a selection from the English Puritans.

2. The Revivalists were a selection from the New England pioneers.

3. The Perfectionists, comprising those who believed in the possibility and obligation of freedom from sin in this world, were a selection from the Revivalists.

4. The Oneida Communists, comprising those who believed in the necessity of human leadership as an auxiliary to direct divine guidance, were a selection from the Perfectionists.

Some of the resulting characteristics of the Oneida Community group were the following:

1. Hardiness. Until 1863 the Community members did the work of farm, factory and household with no hired help. They lived a pioneer life. The

death-rate among them was only 72 per cent of that in New York State total population, 1910. (See table 1.)

2. Longevity. Survival until eighty years of age and beyond was common. Twenty-two died between the ages of eighty-five and ninety-six.

3. Sufficient native ability to carry on successfully a diversified industry and the complex social affairs of a Community.

4. Faculty of agreement. The members of the Community for forty years achieved the miracle of unanimity in all important moves.

The 81 parents of the stirpicultural children may be classified occupationally as follows:

Men

Founder and leader	1
Subordinate leaders	4
Superintendents of departments	13
Foremen	3
Mechanics, artisans and farmers	13
Salesmen, accountants and teachers	5
Inventor and dentist	1
	40

Women

Subordinate leaders	2
Superintendents of departments	2
Editors	3
Forewoman	1
Accountants, reporters and teachers	7
Compositors	7
Housewives	19
	41

It may be further mentioned that two of the superintendents were also editors, that several of those otherwise classified were important contributors to the Community paper, and that eight of the forty men were college graduates.

The standard of individual character aimed at was one in which first the spiritual, second the intellectual, third the moral, and fourth the physical departments of human nature were developed to the fullest extent compatible with the above stated order of precedence. While the terms describing the four "departments of human nature" were not rigidly defined, yet they carry a meaning easily intelligible. Noyes's own conception of them is stated in a "home-talk" dated April 5, 1869, as follows:

> Our nature is like a nest of four boxes. The inner one is the spiritual, the next is the intellectual, the next is the moral, and the outer one is the physical. God will begin to renew us by giving us ruggedness in the spirit, which will enable us to face all devils without fear and live in contact with them without contamination. Then he will give us ruggedness of the understanding, which fears no argument and overcomes all delusions. Then he will give us ruggedness of the moral nature, which keeps its resolutions and submits to no condemnation. And finally through all these mediates he will give us ruggedness of physical health.

The direction of the experiment during the early years was in the hands of an informal committee consisting of the so-called "central members" of the Community, Noyes himself exercising the preponderating influence. On January 25, 1875, a formal "Stirpicultural Committee" composed of six men and six women, two of the members being graduates of the Yale Medical School and the others persons of exceptional experience and judgment, was appointed by the Community and placed in charge. The "Stirpicultural Committee" functioned for about fifteen months, or until April 20, 1876. After this the direction of the experiment passed again into the hands of the "central members" of the Community.

The general methods of selection are indicated by the records of the "Stirpicultural Committee." In a majority of cases application was made to the Committee by couples desiring to become parents, and the Committee, after due consideration, would either approve or disapprove. If an application were disapproved, the Committee would always interest itself in an attempt to find a combination agreeable to those concerned which it could approve. Occasionally the Committee itself took the initiative in bringing about combinations which in their opinion were specially fit.

The degree of selection exercised by the Committee may be judged from the following facts:

1. The death-rate among the 81 selected parents was 22.5 per cent less than that of the group as a whole. (Compare tables 1 and 3.)

2. The fathers of the stirpicultural children averaged 12.2 years older than the mothers. This indicated a certain amount of survival selection among the fathers, and accorded with the principle that quality of offspring is more dependent upon selection among fathers than among mothers.

3. During a typical period of about fifteen months, out of 51 applications from men and women desiring to become parents, 9 were vetoed on the ground of unfitness, and 42 were approved.

4. Exact statistics as to the number of combinations brought about by the initiative of the Committee are not available, but it is probable that about 25 per cent of the births were of this character.

5. Although nearly as many fathers as mothers were engaged in the experiment, 30 of the fathers had only 1 child each, while the remaining 10 had an average of 2.8 children each.

Children were cared for by their mothers during infancy. When able to walk, a child was admitted to the day nursery department of the "Children's House," the mother continuing the night care. From the beginning of the play stage until adolescence the "Children's House" had complete charge, though parents visited their children and received visits from them. Much attention was given to diet, clothing, sanitation and profitable activity, and since epidemic diseases common in outside society were vigilantly excluded sickness among the children was rare. In case of sickness good medical attendance and the best of nursing were immediately available. There were also facilities for quarantine, night watchers, and appliances for comfort and convenience, such as few private families could afford. During the forty years 1841–1880 inclusive, in which a total of 193 children were cared for, only 5 deaths occurred in the "Children's House." At adolescence a young person graduated from the "Children's House," and took his place in the general organization of the Community.

At the re-organization of the Community as a joint-stock company on January 1, 1881, the provisions made for the women and children were these:

The women of the Community participated equally with the men in the distribution of assets in the form of stock, the general basis of division being a proportionate part of the property brought in and an allowance for each year of membership. Several of the mothers who did not immediately marry were given a small extra cash allowance so long as they remained unmarried.

Every child under two and a half years of age received an annual appropriation of $200 in cash, until the age of two and a half was reached.

Every child over two and a half and under sixteen years of age received an annual appropriation according to the profits of the Company, the minimum appropriation being $80 and the maximum $125 per year.

Every child upon reaching its sixteenth birthday received $200 in cash.

The Company obligated itself to maintain a suitable school for children under sixteen years of age free of charge.

The Company also agreed to give preference to the members of the former Community and their children in the matter of employment.

All these provisions were faithfully carried out by the new Company, and no cases of destitution among the women and children of the Community have ever occurred.

A general survey of the Oneida Community stirpicultural experiment will show the following outstanding results:

1. No mothers were lost during the experiment, nor indeed during the entire career of the Community, from causes directly or indirectly due to child-birth.

2. No deaf and dumb, blind, crippled or idiotic children were ever born in the Community.

3. In the group of 44 pre-stirpicultural children, born under the regime of birth-control but not of parent-selection, the death-rate was 82.6 per cent of that in the United States total population, 1870. (See table 2.)

4. In the group of 58 stirpicultural children born during the period 1869–1879, 6 have died up to September 26, 1921. These 6 actual deaths represent 13.3 per cent of the expected deaths in the United States total population, 1870. (See table 4.)

5. The causes of the 6 actual deaths in the group of stirpicultural children were these:

Case 1. Age three days. Atelectasis after instrumental delivery.
Case 2. Age seven years. Scarlet fever contracted during a residence in a large city.
Case 3. Age nineteen years. Brain tumor.
Case 4. Age thirty-nine years. Run over by a railway train.
Case 5. Age forty-four years. Fall with aeroplane while flying for the allies in France.
Case 6. Age forty-five years. Aortic Aneurism.

6. Among the 52 survivors of the 58 stirpicultural births, now at ages forty-one to fifty-one there are two cases of sub-normal development. The first is a man fifty years of age, who has shown since birth a partial lack of muscular coördination, caused probably by cerebral hemorrhage during delivery. His mentality is normal, and his health, except for the defect noted, is good. He was for many years a foreman, and has always been able to support himself by his own labor. The second is a man forty-five years of age, whose mental development was retarded at about the age of seven by an accidental blow on the head which left a permanent indentation on the cranium. Though still slightly sub-normal mentally, he works hard on a farm and in a store, and enjoys reading. Physically he is well-developed. Aside from these two, there are no cases of even partial incapacitation for the normal activities of life.

7. During the stirpicultural period a purposely increased birth-rate coincided with a marked fall in the death-rate. (Compare tables 2 and 4.)

8. In the group of 98 children, one or both of whose parents were stirpicultural, 5 actual deaths occurred during the period 1890–1920, representing 23.5 per cent of the expected deaths in New York State total population 1910. (See table 5.)

9. In the group of 28 children, both of whose parents[1] were stirpicultural, no deaths have occurred during the period 1897–1920. In a group of equal size the number of expected deaths in New York State total population 1910 is 6.2. (See table 6.)

TABLE 1

Comparison of actual and expected results among years of life exposed to risk, September 15, 1880, to close of 1920. 225 Oneida Community members sixteen years of age and above on September 15, 1880.

AGES ATTAINED	YEARS OF LIFE EXPOSED	ACTUAL DEATHS	NUMBER OF DEATHS EXPECTED UNDER MORTALITY RATES OF FOLLOWING TABLES:			
			United States Registration Area 1910	United States Registration Area Rural 1910	New York State total population 1910	United States population 1870 (Elliot)
All ages	5538.65	166	216.1	188.5	230.5	227.2
15 to 19	43.00	—	0.1	0.1	0.1	0.4
20 to 24	93.08	1	0.5	0.5	0.5	1.1
25 to 29	150.00	—	0.9	0.8	0.9	1.8
30 to 34	246.50	3	1.7	1.4	1.9	3.2
35 to 39	349.00	5	3.0	2.3	3.4	4.9
40 to 44	440.25	1	4.4	3.2	5.1	6.9
45 to 49	540.16	2	6.8	4.9	7.8	9.9
50 to 54	610.66	5	9.8	7.0	11.1	13.5
55 to 59	634.98	7	14.8	11.0	16.6	17.7
60 to 64	656.36	14	21.6	16.7	24.1	23.9
65 to 69	603.41	15	28.6	23.6	30.9	29.5
70 to 74	527.56	31	36.6	32.5	38.9	35.5
75 to 79	344.99	32	35.1	32.8	35.9	32.4
80 to 84	197.37	23	30.2	29.6	30.9	26.2
85 to 89	87.33	20	18.1	18.1	18.5	16.5
90 and over	14.00	7	3.9	4.0	3.9	3.8

Percentage, actual of expected mortality among 5,538.65 years of life exposed to risk. Survivals of 225 Oneida Community Members sixteen years and above Jan. 1, 1881, under observation from September 15, 1880, to close of 1920.

TABLE USED AS "STANDARD"	DEATHS EXPECTED	PERCENTAGE ACTUAL DEATHS (166) OF EXPECTED
United States total Registration Area, 1910	216.1	76.8
Rural part of United States Registration Area, 1910	188.5	88.1
New York State total population, 1910	230.5	72.0
Elliott United States, 1870	227.2	73.1

[1] Complex marriage was abandoned August 28, 1879, since which date the members of the Community have married as in ordinary society. Of the 55 stirpicultural children who reached marriageable age, 18 intermarried, 32 married outside the group, and 5 remained single. The results of the 50 marriages are shown in the text and in tables 5 and 6.

TABLE 2

Comparison of actual and expected number of deaths among survivors of 44 Oneida Community pre-stirpicultural births to Oneida Community pioneers. Period of observation, 1847 to 1920

AGE ATTAINED	NUMBER OF YEARS OF LIFE EXPOSED TO RISK	ACTUAL DEATHS	NUMBER OF DEATHS EXPECTED ACCORDING TO DEATH RATES OF FOLLOWING TABLES:				
			United States Registration Area, 1910	Rural part United States Registration Area, 1910	New York State total population, 1910	United States total population, 1870 (Elliott)	Massachusetts Registration Districts 1855 (Elliott)
All ages	1653	27	20.1	16.0	22.1	32.7	31.0
Under 5	179	10	6.5	5.0	6.9	11.0	12.5
5 to 9	166	2	0.6	0.4	0.6	1.5	1.3
10 to 14	163	—	0.4	0.3	0.4	0.9	0.7
15 to 19	159	1	0.6	0.5	0.6	1.4	1.4
20 to 24	140	3	0.7	0.7	0.7	1.9	1.7
25 to 29	140	1	0.5	0.7	0.9	1.7	1.7
30 to 34	134	2	1.0	0.8	1.0	1.7	1.6
35 to 39	124	3	1.1	0.8	1.2	1.7	1.6
40 to 44	108	1	1.1	0.8	1.3	1.7	1.5
45 to 49	98	2	1.2	0.9	1.4	1.8	1.5
50 to 54	94	—	1.5	1.1	1.7	2.1	1.2
55 to 59	72	1	1.7	1.3	1.9	2.0	1.6
60 to 64	42	—	1.4	1.1	1.5	1.5	1.3
65 to 69	25	1	1.2	1.0	1.3	1.2	1.0
70 to 74	9	—	0.6	0.6	0.7	0.6	0.4

Percentage, actual of expected number of deaths. Actual deaths = 27

MORTALITY TABLE USED AS "STANDARD"	NUMBER OF DEATHS EXPECTED	PERCENTAGE ACTUAL OF EXPECTED DEATHS
United States Registration Area, 1910	20.1	134.3
Rural part, United States Registration Area, 1910	16.0	168.8
New York State population, 1910	22.1	138.1
United States total population, 1870	32.7	82.6
Massachusetts Registration Districts, 1855	31.0	87.1

TABLE 3

Comparison of actual and expected number of deaths among survivors of 79 of the 81 parents of stirpicultural children. Births, 1809 to 1858. Observations carried to August 16, 1921

AGES ATTAINED	NUMBER OF YEARS OF LIFE EXPOSED TO RISK	ACTUAL DEATHS	NUMBER OF DEATHS EXPECTED:	
			New York State total population, 1910	United States population, 1870 (Elliott)
All ages, 20 to 89	3931	52	92.9	102.7
20 to 24	395	—	2.0	4.6
25 to 29	391	1	2.4	4.8
30 to 34	390	1	3.0	5.0
35 to 39	381	2	3.7	5.3
40 to 44	375	—	4.3	5.9
45 to 49	372	2	5.4	6.8
50 to 54	360	2	6.6	8.0
55 to 59	348	4	9.1	9.7
60 to 64	320	7	11.8	11.7
65 to 69	283	8	14.5	13.9
70 to 74	189	13	13.9	12.7
75 to 79	83	7	8.6	7.8
80 to 84	30	2	4.7	4.0
85 to 89	14	3	3.0	2.6

Percentage, actual of expected number of deaths. Actual deaths = 52

MORTALITY TABLE USED AS "STANDARD"	NUMBER OF DEATHS EXPECTED	PERCENTAGE ACTUAL OF EXPECTED DEATHS
New York State total population, 1910	92.9	56.0
United States total population, 1870	102.7	50.6

TABLE 4

Comparison of actual and expected number of deaths among survivors of 58 stirpicultural births in the Oneida Community. Births, 1869 to 1879. Observations carried to September 26, 1921

AGES ATTAINED	NUMBER OF YEARS OF LIFE EXPOSED TO RISK	ACTUAL DEATHS	NUMBER OF DEATHS EXPECTED UNDER MORTALITY RATES OF SPECIFIED TABLE:			
			Rural part of United States registration area, 1910	United States Registration Area total table, 1910	New York State total population, 1910	United States total population, 1870 (Elliott)
All ages	2638	6	19.7	24.7	26.6	45.2
Under 5	285	1	18.0	10.3	11.0	17.7
5 to 9	283	1	0.7	0.9	1.0	2.6
10 to 14	280	—	0.6	0.6	0.6	1.6
15 to 19	280	—	0.9	1.0	1.0	2.4
20 to 24	275	1	1.4	1.4	1.4	3.2
25 to 29	275	—	1.4	1.6	1.7	3.4
30 to 34	275	—	1.6	1.9	2.1	3.5
35 to 39	275	—	1.8	2.4	2.6	3.8
40 to 44	255	1	1.9	2.6	2.9	4.0
45 to 49	134	2	1.2	1.7	1.9	2.5
50 to 54	21	—	0.2	0.3	0.4	0.5

Percentage, actual of expected number of deaths among survivors of 58 stirpicultural births in the Oneida Community. Expected deaths computed from mortality rates of specified tables. Actual deaths = 6

MORTALITY TABLE USED AS "STANDARD"	NUMBER OF EXPECTED DEATHS	PERCENTAGE, ACTUAL (6) OF EXPECTED NUMBER OF DEATHS
Rural part of United States Registration area, 1910	19.7	30.5
United States Registration Area, 1910	24.7	24.3
New York State total population, 1910	26.6	22.6
United States total population, 1870 (Elliott)	45.2	13.3

TABLE 5

Comparison of actual and expected number of deaths among survivors of 97 births, one or both of whose parents were stirpicultural. Births, 1890 to 1917. Observations carried to 1921.

AGES ATTAINED	NUMBER OF YEARS OF LIFE EXPOSED TO RISK	ACTUAL DEATHS	NUMBER OF DEATHS EXPECTED
			New York State total population, 1910
All ages	1480	5	21.3
Under 5	464	4	18.0
5 to 9	428	—	1.5
10 to 14	345	—	0.8
15 to 19	170	—	0.6
20 to 24	61	1	0.3
25 to 30	12	—	0.1

Percentage, actual of expected number of deaths

New York State population, 1910 as "standard": 23.5

TABLE 6

Comparison of actual and expected number of deaths among survivors of 28 births, both of whose parents were stirpicultural. Births, 1897 to 1917. Observations carried to 1921.

AGES ATTAINED	NUMBER OF YEARS OF LIFE EXPOSED TO RISK	ACTUAL DEATHS	NUMBER OF DEATHS EXPECTED	
			New York State total population, 1910	United States population, 1870 (Elliott)
All ages	412		6.2	10.7
Under 5	138	—	5.3	8.5
5 to 9	124	—	0.4	1.2
10 to 14	96	—	0.2	0.5
15 to 19	42	—	0.2	0.4
20 to 24	12	—	0.1	0.1

Percentage, actual of expected number of deaths. Actual deaths = 0

MORTALITY TABLE USED AS "STANDARD"	NUMBER OF DEATHS EXPECTED	PERCENTAGE, ACTUAL OF EXPECTED DEATHS
New York State total population, 1910............	6.2	None to be computed
United States total population, 1870................	10.7	

TABLE 7*

Summary: Comparison of actual and expected number of deaths in various Oneida Community groups

GROUP	ACTUAL DEATHS	EXPECTED DEATHS ACCORDING TO CONTEMPORARY TABLES	PERCENTAGE, ACTUAL OF EXPECTED NUMBER OF DEATHS
44 pre-stirpicultural births	27	32.7	82.6
225 Oneida Community members, 16 years of age and over on September 15, 1880	166	227.2	73.1
Parents of the stirpicultural children	52	102.7	50.6
Children, one or both of whose parents were stirpicultural	5	21.2	23.6
The stirpicultural children	6	45.2	13.3
Children both of whose parents were stirpicultural	—	6.2	—

* The Scandinavian method of computing the ratio of actual to expected mortality has been used in these tables rather than the method of computing the death rates per thousand as being more accurate for small groups. The death rates per thousand used in computing the expected deaths are given below:

Death rates per 1000 at specified central ages of five year age groups. Population mortality tables used to test Oneida Community mortality data

AGE GROUP	DEATH RATES PER 1,000				
	United States Registration Area, 1910	Rural part of United States Registration Area, 1910	New York State, total population, 1910	United States total population, 1870 (Elliott)	Massachusetts Registration Districts, 1855 (Elliott)
Under 5	36.29	27.96	38.72	61.92	69.84
5 to 9	3.30	2.51	3.55	9.27	7.78
10 to 14	2.22	2.02	2.17	5.66	4.35
15 to 19	3.52	3.29	3.52	8.50	8.78
20 to 24	5.19	5.13	5.10	11.75	10.75
25 to 29	5.85	5.24	6.10	12.18	11.88
30 to 34	7.09	5.66	7.71	12.87	12.19
35 to 39	8.59	6.48	9.62	13.97	12.58
40 to 44	10.09	7.26	11.53	15.67	13.43
45 to 49	12.63	9.02	14.41	18.25	14.81
50 to 54	16.01	11.54	18.21	22.12	18.36
55 to 59	23.37	17.26	26.15	27.89	22.32
60 to 64	32.96	25.37	36.73	36.42	31.94
65 to 69	47.41	39.04	51.14	48.96	39.73
70 to 74	69.38	61.56	73.70	67.30	48.38
75 to 79	101.74	94.95	104.14	94.01	107.05
80 to 84	153.06	150.08	156.72	132.77	166.26
85 to 89	206.84	206.71	211.35	188.82	229.82
90 to 94	279.90	285.86	276.04	269.69	280.34
95 to 99	354.55	382.71	365.31	386.03	315.78

We wish to express our hearty appreciation for the assistance on the construction of the mortality tables given by Mr. Edwin W. Kopf, assistant statistician of the Metropolitan Life Insurance Company.

SOME FAMILIES AS FACTORS IN ANTI-SOCIAL CONDITIONS

AMOS W. BUTLER

Indiana Board of State Charities, Indianapolis

One of the first undertakings of the Board of State Charities of Indiana, after it was established in 1889, was to ascertain how many persons were inmates of the state and local institutions and, later, who these persons were, some facts of personal history and the reason they were public charges. The information, collected by means of institution reports, was transferred to a card registration. Beginning modestly with the inmates of ninety-two county poor asylums and four state hospitals for the insane, the registration contained abut 5700 names at the end of its first year. From time to time other institutions were added, and the reports were made to include something of both personal and family history. All this was properly carded.

The registration now contains over 158,000 names of persons who are, or within the past thirty-one years have been, inmates of eighteen state charitable and correctional institutions, ninety-two county poor asylums and thirty-three orphans' homes. It is maintained in duplicate, one set being arranged by institutions, the other alphabetically and phonetically. It is the latter that brings family names together, and no one can glance over the cards without being impressed by the frequency with which feeble-mindedness or a related defect appears on these records. It was from them in 1896 that Mr. Ernest P. Bicknell, then secretary of the board, made a study of 248 families, selected because of feeble-mindedness in one or more generations. Concerning these records, Mr. Bicknell well said:

> They are not clean cut, not properly rounded out. They begin in obscurity, come into view for a few years, and fall back into obscurity again. But the broken stories of their misery, their perpetuation of their own wretched kind, their demoralizing influence upon their fellows, their dragging down of the average of morality, intelligence, and physical development, are sorrowful beyond words.[1]

Eleven years afterward it was my privilege to present to the National Conference of Charities and Correction a similar study from this registra-

[1] National Conference on Charities and Correction, 1896, page 219.

tion, of 803 families, more than half the members of which were feeble-minded.[2]

Beside this card registration of institution inmates, the board has a record, by name, of every family aided by official out door poor relief, of every person received at a county jail, of every child born in a maternity hospital. All these make available a vast amount of information concerning public dependents. Out of it has grown a desire for still more data, and one result was the appointment by the governor in 1915 of a committee to study the whole problem of mental defectives and suggest a program for their care.

This committee has surveyed ten of our ninety-two counties, listing every feeble-minded, epileptic or insane person, found 5322 in all, an average of 2.1 per cent of the population of those ten counties. On this basis, Indiana has 56,718 mental defectives—44,284 feeble-minded, 8311 insane and 4123 epileptics. It is estimated that 25,232 of these do not need institutional care, but of those who do need it, the state is now caring for 79 per cent of the insane, 23 per cent of the epileptics and but 7 per cent of the feeble-minded. It is plain, therefore, that it is the feeble-minded who constitute our most serious problem. We have but two state institutions for them a school at Fort Wayne, a colony farm at Butlerville. Together they have about 1500 inmates—a very small porportion of the number in our state who need institutional care. Where are the rest? They are in institutions not suitable for them, or they are at large in the communities.

More than half the inmates of our county poor asylums are mental defectives. They wander in and out almost at will. Usually present in large numbers in the winter months, they leave when spring comes, and roam about the country, satisfied with whatever offers shelter,—an old hut or sometimes a rail pen.

Because the state school for feeble-minded youth is crowded, our orphans' homes are gradually filling up with children who cannot be placed with foster parents. A study of 225 dependent children in one institution disclosed 22.6 per cent mental defectives.

Many of our prisoners are feeble-minded. "Mental defect is good soil in which to develop crime." The ten counties surveyed by our committee were represented in the Indiana State Prison by 69 men, of whom 60.8 per cent were mental defectives.

Of nearly 1000 school children tested by the Binet-Simon method, from 2 to 3 per cent were found feeble-minded and 10 per cent in need of special

[2] N.C.C.C., 1907, page 1.

instruction. They were receiving no benefit themselves in the public schools, and were hindering the progress of normal pupils.

In our records of official outdoor relief, we usually expect to find defectives in about one-fourth of the twenty thousand families aided annually. These people are living in their own homes, or in some deserted shanty, depending on charity, to eke out a miserable existence.

What kind of homes do they have? Let me quote from an investigator's report on some of them:

> The dirt, disorder, filth and cluttering are indescribable. Animals wander in and out. Garbage on the table, piles of filthy clothing on the floor, food stored under beds, an awful stench arising from the filth. . . . . The yard of one house a jungle of harness, ropes, old buggies, broken cots, cans, old iron, wheels. In the house the beds are piled high with dirty rags. One room so cluttered with old furniture that a pathway to the beds is the only unoccupied space. . . . . Many homes dilapidated. Isolation remarkable. Roads are just ruts and ditches.

The records which have been accumulating in our office for the past quarter of a century, and more recently those collected by the Committee on Mental Defectives, while somewhat in the nature of a census, yet contain in some cases many generations of family history. Now and then when a particular name occurred with unusual frequency or a particular locality seemed unduly represented in public institutions, a special investigation has been made. In one way and another, hundreds of degenerate families have been listed, some going back as far as seven generations. Among them are scores of references to the Tribe of Ishmael, which is to Indiana and the central west what the Jukes are to New York and the Kallikaks to New Jersey, though a much larger group than these or any other that has so far been studied. While these family records are strikingly similar, some are noted for a particular trait or tendency. There is, for example, a family in eastern Indiana, of which the mother and ten of her eleven children are mentally unbalanced. Two sons and two daughters of this family committed suicide. Another daughter with two children threatened their lives and her own. Their maternal grandfather met death by his own hand.

A family which has long been a veritable hotbed of immorality lives in southern Indiana. One woman, whom we will call "Polly," is known to have eleven illegitimate children, each with a different father. One of Polly's daughters, feeble-minded like her mother, has had eight illegitimate children, seven of whom are of the same mental caliber. One of these seven has had four illegitimate children. In this one group there have been twenty-three illegitimate children, the offspring of three feeble-minded women. Altogether, Polly has fifty-six lineal descendants, thirty-one of whom are feeble-

minded and eighteen of whom have been inmates of public institutions. Sixteen of the eighteen are known to have spent a total of seventy-two years on public support, at a cost of $10,800. This is one branch of a family group of 477 individuals representing seven generations. The younger members are still a serious problem in the life of their community.

In another county is a family group of 152 individuals, notorious not only for shiftlessness and immorality, which so often characterize these records, but also for crime. Fourteen of its members have police court records, three have been convicted for serious crimes, one has been in a reform school.

The writer once had ranged before him in a county poor asylum four feeble-minded persons: a man, his daughter, grand-daughter and great grandson—four generations, all living at public expense.

Thirty years ago a young feeble-minded woman was admitted to one of our county poor asylums. A year later a blind man became an inmate. The two became acquainted and in time were married. Their wedding occurred in the poor asylum, they set up their family altar there and to them were born five children, all in the institution. Quite recently one of their daughters was committed to the Woman's Prison for perjury, in connection with statements concerning her illegitimate child, who is now in an orphan's home. In this case, as not infrequently happens, public officials connived at that which later brought a heavy burden of expense and disgrace upon their community. They "knew not, and knew not that they knew not."

One could fill a book with these Indiana stories of misery and degradation, of sin and suffering and crime, of public ignorance, indifference and neglect. And they could doubtless be duplicated in ever state in the Union. Everywhere our people have failed to realize what was happening and these weaker children of the land have grown incredibly strong in numbers and in power for evil. More than once I have taken occasion to say that feeble-mindedness is one of the most potential destructive factors in our civilization. It produces more pauperism, more crime, more degeneracy, than any other one force. It is a fact we have to face, a condition we have to meet, a power we must keep under.

PEDIGREES OF PAUPER STOCKS

E. L. LIDBETTER

London, England

In asking me to prepare a paper on this subject for the Second International Eugenics Congress, Major Leonard Darwin no doubt had in view the fact that I have been engaged in an investigation as to family pauperism for many years past.

As a result a considerable number of pedigrees—some 400 to 500—have either been prepared or are in course of preparation. The examples here submitted are the more interesting of those already completed.

As the Congress is of an international character it is necessary to say that the term "pauperism" is used in this paper in its strictly legal and official sense as understood in England. That is to say only such persons are so described as are or have been maintained wholly or in part by funds raised out of public rates levied and administered by a board of guardians, duly elected for that purpose by the ratepayers. All other forms of public and private assistance are disregarded in the pedigrees.

Until a few years ago it would have been possible to say that all assistance afforded out of public funds was administeredby the poor law guardians and therefore fell within the term "pauperism." This, however, is no longer the case, vast sums of public money being now expended by public authorities other than the poor law guardians, among which may be mentioned:

a. Old age pensions, administered by special commissioners.

b. Feeding of school children by education authorities.

c. Relief afforded by public health authorities in cases of sickness and maternity.

d. Maternity homes and other non-contributary hospitals provided by public health authorities out of local rates.

e. Unemployment relief provided from imperial funds (i.e., from taxation and not from local rating). The latter nominally a contributary scheme of unemployed insurance, but actually as now administered non-contributary relief in unemployment—in many cases supplemented by the Poor Law Guardians out of local rates.

To those who have not given careful attention to the subject the preparation of pedigrees in relation to pauperism seems to imply that pauperism as such is hereditary. No such proposition is put forward in this paper. But it *is* contended that the pauperism is a consequence of inherent and transmissible defects of character, and that pauperism is dependant upon mental, moral and physical defects, standing in relation to the pauperism as cause to effect, such as render the individual unable to hold his own in the competition for existence so that he fails to be at all times self-supporting—often for considerable periods.

To a gathering assembled in the name of Eugenics it will not be necessary to argue at length that pauperism is to be attributed to bad heredity, either in the sense of the actual transmission of defect, or the perpetuation of low-grade types. The really important question is as to what proportion of existing pauperism can be shown to be due to those causes. In this unfortunately there exists no data for our guidance, and I regret that I am unable to supply that deficiency.

In 1913 I commenced an investigation which would, if completed, have been of assistance in this respect; but the enquiry was unfortunately abandoned when war conditions made it impossible to carry it on. In passing, it should be observed that the gradual disintegration of the Poor Law service now going on by the introduction of parallel services as indicated above, will greatly hamper—if not render impossible—any attempt at a comprehensive investigation in the future. The complete coördination of the whole public assistance service is essential to such an investigation.

In these circumstances it must be understood that the diagrams submitted herewith of particular cases are selective. They are unquestionably representative of a great mass of pauperism in England—particularly in the great towns. But it is not possible to say what proportion of the whole they represent.

In all the official investigations with regard to pauperism in this country no attempt has ever been made to analyse or define the personality of the pauper, his character, antecedents or capacity. Mass statistics have been produced, reduced to some rough classification and inferences drawn from the result. The effect has been to obscure the essentially personal element, so that the problems involved have come to be regarded as purely economic problems; and no doubt much modern legislation is based upon this wholly mistaken view.

All engaged in the administration of the Poor Laws have long been struck by the tendency of particular individuals and particular families to apply to the relieving officer in almost every domestic contingency, and indeed

for whole families to spend their lives in intermittent chargeability. To what extent does this practice obtain and in what proportion does it stand to the sum total of pauperism?

Taking the inmates of the workhouse and hospital of a small parish in the east end of London on a particular day in the year 1913 the following figures show the number of those present on that day and the number of times which the several individuals had been previously admitted as inmates:

NUMBER OF TIMES ADMITTED	NUMBER IN WORKHOUSE	NUMBER IN INFIRMARY	TOTAL
First admission	445	240	685
Second admission	197	74	271
Third admission	106	41	147
Fourth admission	62	25	87
Fifth admission	39	18	57
Sixth admission	29	9	38
Seventh admission	11	7	18
Eighth admission	18	7	25
Ninth admission	11	3	14
Tenth admission	11	2	13
More than 10 and under 20	26	13	39
More than 20 and under 30	16	5	21
More than 30 and under 50	11	1	12

Among workhouse cases, 1 each of 53d, 63d, 77th, 96th, 110th, 113th, 130th, 152d, and 184th time of admission. Among infirmary cases, 1 each of 55th and 115th time of admission. These latter would of course be extraordinary cases. Mainly men allowed out from day to day to look for work—who seldom found it.

I would illustrate this latter point by giving the details of a particular case:

Case of man Owen. Born 1859. Single. Cabinet maker. First entered workhouse in February 1905, at age of forty-six years. Was "in and out" on 108 occasions and finally left in January, 1916, when the war-time call for men had reduced the standard of employable labor. During this time the longest period out of the workhouse was 271 days and the longest period in as an inmate was 231 days. In the whole period there were 3990 days: he spent 2397 of these in the house and 1593 out. Average duration of each stay in the workhouse a fraction over 22 days, average stay out of it a fraction over 15 days.

On 106 occasions (not counted in the above figures) he discharged himself in the morning to look for work and returned the same evening. If these are added to the other 108 admissions it gives 214 occasions upon which the official machinery attending admission to the workhouse was put into operation by this man in a period of 10 years and 11 months, out of which he spent a total of 6 years, 6 months and 20 days in the workhouse.

The generality of these figures (p. 393) would no doubt have been greatly reduced by an examination of the family relations of the individuals concerned. This was in fact attempted, but the variety of the relationship and the labour required for the investigation was so considerable that the attempt broke down and had to be abandoned—one of the consequences of the outbreak of war.

The symbols used in the preparation of these pedigrees are as follows:

1 2 3 4 5 6 7 8

1. Normal.
2. Particulars not known.
3. Occasional pauper.
4. Chronic pauper.
5. Reared in pauper schools.
6. Insane pauper.
7. Died in infancy.
8. Imbecile.

Letters added to the symbols:
T = Tuberculous.
B = Blind.
E = Epileptic.
D = Deaf and dumb.

Note. Where the lines denoting relationship are disconnected or broken (thus, - - - - - - - - - - - -) it indicates that the parents were not married.

Although the actual pedigree charts are not reproduced in this paper some idea of their findings can be gathered by an examination of the pedigree-summaries of the following families:

FAMILY I. A GROUP OF MILDLY INCOMPETENT PERSONS IN SIX GENERATIONS. VERY LITTLE SICKNESS INDICATED

Paupers:		Non-paupers or unknown:	
Chronic	13	Died in infancy	21
Occasional	64	Known non-paupers	55
Insane	6	Unknown	31
Reared in poor law schools	7		
Total	90	Tuberculous	10
		Epileptic	3
		Blind	1

On the date when the investigation commenced in 1913, seven of these were chargeable: six in the area under investigation and one beyond. These seven have a collective period of chargeability amounting to 66 years and seven months. Others in the group between them (as far as can be ascertained) 142 years; giving a total in the group of 275 years.

The four brothers shown in the third generation at 8, 9, 10, and 11 are representative of the whole.

No. 8. Entered workhouse at 60 years of age: was out for two short periods, average 35 days each, and had at the date of enquiry been in the house continuously for six years and 5 months. Total chargeable period at that time 7 years and 11 months.

No. 9. Entered house at 43 years of age, and has not since been out. Chargeable period 26 years. Has a club foot.

No. 10. Entered at the age of 34 years. Total period chargeable on the appointed day 15 years and 8 months. Last period unbroken 7 years and 7 months. Has been out 22 times, average stay out 7 months and 1 day. Total period out since he first came in 13 years 2 months 13 days.

No. 11. Entered at 26 years of age. Total period chargeable at the appointed day 20 years, 9 months, 17 days. Last period unbroken 4 years. Has been out in all 60 times, average 2 months 13 days. Aggregate period out since he first came in 12 years, 3 months 13 days.

Of these four brothers two were unmarried, and the others had wives and children. The wives carried on the homes after the men entered the workhouse.

Family II. A Group of Vicious Non-moral Individuals

Illegitimacy. Crime and Desertion. This illustrated by the large number of children reared in Poor Law schools.

Paupers:	
Chronic	20
Occasional	44
Insane	3
Reared in Poor Law schools	26
Total	93

Family III. Insanity and Eye Disease in Six Generations

Paupers:			
Chronic	2	Non-paupers:	
Occasional	56	Normal	30
Blind	7	Not known	23
Insane	10	Died in infancy	10
Blind and insane	5		
		Not known includes 13 parents of 81 children.	
Total	80		

Professional men and others interested in Family III will find it set out in greater detail in "Brain" volume 35, part 3 (1913).

These three large families have been selected for this paper because they show in such a clear way the three distinct classifications in these groups—the inheritance of mental disorder, the low grade type of mildly incompetent persons, and the distinctly non-moral group. Generally speaking these classes are found in combination all in the same group, but here they are found clearly defined and are so presented.

From this point of view it is particularly interesting to notice their combination in marriage and reproduction, for not only do they reproduce as the biological students would expect, but like attracts like in marriage to

a remarkable degree. It needs only a paternal Poor Law system, easy of access, to ensure the survival value of these types and their multiplication.

Only a want of space and time prevent me showing other pedigrees as large and important as these. I would point out too that these are pedigrees collected in the area of a single Poor Law authority—and that a very small one. The pauperism shown is of course the minimum. In few parishes are records available for more than thirty years and in fewer still are they intelligible over that period. It follows that there may have been in each pedigree a larger number of paupers than is here shown. Furthermore the period of the earlier generations shown is back to the limit of the memory of the available witnesses—another limiting difficulty.

It is necessary to define more clearly the attitude of Eugenics to pauperism. In so far as pauperism is of a temporary character—as for instance in non-recurrent temporary sickness, or relief for the family of a man bona fide unemployed, or in the case of orphans maintained in Poor Law Schools whose parents were not suffering from diseases known to be hereditary—we are concerned in the matter only to the extent that eugenics requires the best environment for the biologically desirable. This is, however, a sort of side issue of eugenics proper and many no doubt will deny that it has any relation to eugenics. We are mainly concerned with the poor law in so far as pauperism is in relation to hereditary defect and its reproduction. Two questions are cardinal to the issue before us. Can it be shown that there is in existence a definite type of pauper family? Secondly and if so, is the pauperism in those families associated with a definitely transmissible characteristic standing in relation to the pauperism as cause and effect?

I think there can be no doubt that the figures and the pedigree-summaries I have put before you answer, and abundantly answer, the first question in the affirmative.

With regard to the second question the pedigree-summaries have been specially selected because they do show in each case a definitely transmissible characteristic not only associated with pauperism, but standing in relation to it as cause and effect. It is of the very greatest importance in this investigation that we should realize that whenever these pedigrees have been developed to a sufficient size, in each case the distinctive quality of that case has become apparent. This is the most important fact brought out by this series of cases. Not only is the distinguishing characteristic observable in each generation, but the inter-marriages are with the same type until the pedigree broadens out and is absorbed in the general community.

In addition to these three large pedigree-summaries, I have described and charted four smaller ones, which should be of some interest to Mendelians and others interested in indirect transmission.

I would summarise this paper by submitting the following general propositions:

1. That there is in existence a definite race of chronic pauper stocks, intermingled with the general community, not recruited to any large extent from the normal population, and not sensibly decreased by the agencies for the promotion of human efficiency. (The proportion this class bears to the total number of persons chargeable is unknown, but it must be considerable and some enquiry should be instituted to determine the fact).

2. That modern methods of public and private charity tend to encourage the increase of this class by relieving the parents of the normal responsibilities of parenthood.

3. That the tendency of all modern movements in matters relating to the care and upbringing of children, is and must continue to be towards a very large increase in parental responsibility, and as this movement goes on, the right of the community to decide as to the kind of children it is to shelter and maintain should increase also.

4. That the development of Poor Law administration in the future should be towards its perfection as an organisation for the reception and care of those mental and physical degenerates, whom it now seems that all human communities must produce.

5. That the reduction of this class may be brought about by a due observance of the laws of heredity, so far as they are surely known, and that that reduction may become progressive in proportion as our knowledge grows.

THE TRIBE OF ISHMAEL

ARTHUR H. ESTABROOK

Eugenics Record Office, Carnegie Institution of Washington

In 1877 Dugdale published the story of the Jukes, calling it a study on Crime, Pauperism, Disease and Heredity, and giving in it the sociological history of six hundred people, all descended from five sisters, showing how the same anti-social traits have continually appeared for six generations. He said that these "Jukes" were but a few of a big class.

A little later, in the same year, a minister of the gospel in Indianapolis, Indiana, read the Juke book and was very much impressed by the description of the folk and the generalization drawn by Dugdale. At about the same time he found the following case of destitution in that city. The following is quoted from his diary:

> A family, composed of a man, two children, the woman's sister and child, the man's mother, blind, all in one room ten feet square. One bed, a stove, no other furniture. When found they had no coal, no food. Dirty, filthy, because of no fire, no soap, no towels. It was the most abject poverty. I have never seen anything like it. We carried supplies to them.

Two days later in his diary:

> The case alluded to under the date of Friday seems to be a case similar to that of the "Jukes." I went to the office of the township trustee and found them under the name of the Ishmaelites.

The story of how the name "Ishmaelite" had come on the books of the township trustee is of interest. I may add at this point that in Indiana the township trustee is the official whose duty it is to oversee the giving of poor relief. From 1800 to 1850 many families from eastern Kentucky and southern Ohio for divers reasons were moving west. Many of these were the industrious, ambitious, hard-working peoples who were moving on to make a new home "further west." These are not of interest to us sociologically. Some of these had left their homes with no preparation for a journey across what was in those days almost a wilderness. And so many of them were forced to beg for food and sustenance when they came to a settlement. Indianapolis was the first big "stopping place," and the people

were generous. And so Indianapolis came to be noted as a place where the people were friendly and very willing to help others who too were moving west into new habitats. This friendliness and generosity were soon to be taken advantage of and wanderers came to Indianapolis knowing that they would be cared for. During this period then Indianapolis became the home of many families who were dissatisfied with the harder struggle for existence in the developing country in Kentucky and Ohio and those who had the restless wandering spirit. These latter could travel when the weather was good and return to Indianapolis for the winter and live through this period by begging in the city just as in the summer they begged their way on the roads. There were quite a number of these families who disregarded the law of the land, who did much as they wanted to do and cared little for the opinion of others. They wandered from place to place. The men were shiftless; the women, immoral, and the children, ill-fed and clothed, the typical feeble-minded people who are so easily recognized today. How many of these families there were is not known but a rough estimate would place it at not less than four hundred. It is these families and their offspring and interconnections that formed the greater part of the pauper population of Indianapolis of years ago.

The amount of poor relief given in Indianapolis had become so great that in 1876 a systematic effort was made to study this pauperism in the city and make plans to reduce it. A system of historical records was devised covering the names and social condition of these applicants for relief; making special note of all relatives, this for the purpose of finding any who might help the applicant. Visitors were also employed to call at the homes of the applicants to make careful investigations. The frequency with which the same names appeared in the lists of relatives of applicants and the family likenesses of individual applicants soon led to the conclusion that these paupers were one large closely related group and so received the name, "the Ishmaelites," from the Ishmael family, the name of the central and worst family of these paupers. It was at this time that the Rev. O. C. McCulloch became interested in these people as mentioned above, saw the similarity of them to the Jukes, noting, however, the difference that this large set of people came from several hundred different family heads whereas the Jukes had all come from the one mother with five daughters.

In 1888, McCulloch read a paper at the National Conference of Charities and Corrections at Buffalo, presenting a diagram where thirty different family groups of paupers had been traced out covering about two hundred and fifty separate families or households. He says,

> The central family—that which gives its name to the Tribe of Ishmael—first appears in Indianapolis about 1840. The original family stem, of which we have scant records as far back as 1790, is then in Kentucky, having come from Maryland through Pennsylvania. John Ishmael married a half-breed woman and came to Marion County, Indiana, about 1840. He was diseased and could go no further. Three of his sons married three sisters from a pauper family named Smith.
>
> Since 1840, this family has had a pauper record. They have been in the almshouse, the House of Refuge, the Woman's Reformatory, the penitentiaries and have received continuous aid from the township. They are intermarried with the other members of this group and with two hundred and fifty other families. In this family history are murders, a large number of illegitimacies and of prostitutes. They are generally diseased. The children die young. They live by petty stealing, begging, ash-gathering. In summer they "gypsy" or travel in wagons east or west. In the fall they return. They have been known to live in hollow trees or the river bottoms or in empty houses.
>
> In this sketch three things will be evident: First, the wandering blood from the half-breed mother; in the second generation the poison and passion that probably came with her. Second, the licentiousness which characterizes all the men and women, and the diseased and physically weakened condition. From this result mental weakness, general incapacity and unfitness for hard work. And, third, this condition is met by the benevolent public with almost unlimited public and private aid, thus encouraging them in this idle, wandering life, and in the propagation of similarly disposed children.

Thus McCulloch tells of the conditions in 1888. Soon after this report McCulloch died and the study stopped at that point. Some of the original data have been lost; the official records are mainly extant. About 1915, the Eugenics Record Office took up the study of the Tribe of Ishmael at the point where it had been dropped at McCulloch's death and the work has been carried on to the present except during the time of the participation of the United States in the World War.

The present investigation has shown that the different families of the Tribe came to Indiana, separately in most cases, on the general tide of immigration west from the original thirteen colonies along the seaboard just following the War of the Revolution. The early immigration into Indiana was mainly from southwestern Ohio and Kentucky. These people in turn had come either from the Carolinas through the Cumberland Gap or Tennessee or from Virginia, Maryland and Pennsylvania, overland by way of the Potomac River, over the mountains and then down the Ohio River. The make-up of the population of Virginia in Colonial days gives a clue to the origin of the Ishmaelites of Indiana. Labor was scarce in Virginia at that time and the Virginia Company to fulfil its contract brought to this country "idlers" and members of the classes in England who were "chargeable, dangerous and troublesome to the State," and youthful vagabonds and later convicted criminals, some political but more the common, the anti-social, these latter being sent here to serve out their terms and then to

be set free in this country. After 1650, the deportation of confirmed criminals, i.e., felons, to the American Colonies was a common practice.

That not all of these anti-social persons sent to the Colonies were men is shown by an entry, one of many, of a ship leaving Lieth, England, in 1692 "for Virginia, holding 50 lewd women out of the houses of correction and 30 others, who walked the streets after ten at night." This deportation continued until about 1770 but there are no figures as to the number who came here. In the lists of criminals that are now extant, some of the family names of the Tribe are found and very many more names are found in the lists of servants, i.e., people indentured or sold, because of criminal acts in England, for a term of years to planters. Although no actual lineage connection between these individual names and the Tribe family heads has been made the fact is interesting and suggestive of much. It is reasonable to assume that some of the Tribe families have gone back to these paupers, criminals and prostitutes sent to the Colonies. Some of the Ishmael names are very uncommon, which fact aids in this conclusion.

It is estimated that the Tribe numbered six thousand people in 1885, coming from about four hundred different family heads. Today no estimate of the number of Ishmaels can be made because many of the lines of descent have been lost and so cannot be traced, but the number would not be less than ten thousand. They are now found mainly in Indiana, Kentucky, Illinois, Ohio, Michigan, Iowa and Kansas.

There are three outstanding characteristics of the members of the Tribe; pauperism, licentiousness and gypsying. In a paper such as this, statistics and family histories are of little value to tell the story and are out of place. Cases could be cited endlessly where a family for generation after generation have been professional beggars and paupers, receiving both public and private relief. The names of these families are found year after year on the township trustee books and soon the children, now as parents, appear under their own names, asking for help. In the same way the professional beggars tour the town both in the residential and business districts with always a pitiful tale, which never bears investigation, sometimes the eyes washed with bluestone water to make them inflamed and the individual claiming blindness, or an injury to the hand or foot, kept irritated for months as a plea for help and an excuse for unemployment. There is hardly a family in the Tribe that has not had some beggars; in many of the families almost all the members are adept in the art of begging and have plied their trade for years. They always carried a basket, sometimes with dirty soap or bluing as a pretext to call, but the basket was ready to hold anything that would be given, either clothing, food or money. As blindness has been

quite common in several families of the Tribe, a familiar sight had been a blind man or woman led by others begging from house to house. Young children too have been taught to beg. The amount of the actual relief or help secured by the Tribe far exceeds anything given to the Jukes or the Nams. No estimate of this can ever be made. When the struggle has been too hard often indoor care for members of the Tribe has been furnished in poor asylums or other institutions. Many have spent the last years of their lives in almshouses. It has not been uncommon for three generations in one family to be in the poor house at the same time.

Licentiousness is perhaps the next interesting trait which has characterized the Tribe. The loose marriage relationship has been one of the outstanding features. A fair proportion of the marriages in the Tribe have been according to the law, both parties legally free, a license secured and the marriage ceremony performed either by a clergyman or a justice of the peace, with the two persons concerned remaining together until the death of one. There have been many cases where two people have merely cohabited under the common law marriage and children born under these conditions have been considered legitimate. Divorce has been very easy in Indiana. Many of the Ishmaels had no comprehension of or respect for the marriage vows and so their consorts were left or changed at will. One example of this will indicate the extent to which it existed in one family even though this is an extreme case. Four members of one fraternity, one man and three women, each had respectively, six, five, five, and seven marriages or matings; in no case death causing a separation, no divorce actions completed and only about half of the matings accompanied by a marriage ceremony. A daughter of the woman who had seven marriages was herself a prostitute, married ten times, several of these by ceremony—no divorce between any two marriages.

Prostitution as will be seen from the above was common in the Tribe. At one time the greater proportion of the women keeping houses of prostitution in Indianapolis belonged to the Tribe. Several of these houses were famous in this region of the state. The elegance of a few of these houses of prostitution in the late sixties, seventies and eighties of this past century in Indianapolis is often recalled by older police officials and newspaper reporters who were familiar with the inside of these establishments. The Ishmaelites often used members of their own families as inmates of these houses. In one a woman and her two granddaughters, while in several cases a woman and her daughters, comprised the personnel of the bagnio. Many other Ishmaelites frequented houses of prostitution merely as casual inmates. There were many homes among the Ishmaels where illicit relationships

occurred. Some incest has been found in the Tribe. No figures as to the number of people married, divorced, children born in or out of wedlock, etc., are presented because of the lack of official registration covering these points. It can be said that the illegitimacy is greater than in either the Jukes or Nams.

The other marked characteristic of the Tribe has been the wandering or "gypsying" as it is called by the Ishmaelites. The earliest known of these "American gypsies" as they were called, was John Ishmael, who had come to Indianapolis from Kentucky about 1825. In the next few years he made several gypsy trips towards the Ohio River and Cincinnati. As this country became settled these trips turned to the north part of Indiana into the Indian reservations. These reservations covered over fifteen hundred square miles and were open only to Indians but these gypsies, much more numerous by this time, seem to have been permitted at all times to enter them to hunt and fish. Here these people gypsied during the summer months, returning to Indianapolis for the winter. It was upon these trips that many of the early marriages of the Tribe have taken place. After 1845, northern Indiana was being settled rapidly and the Indians were gradually being pushed from the reservations. The gypsyings therefore ceased in this direction and started out again in a land less highly developed. This time the route was to the plains of Illinois and sometimes as far as Iowa and Kansas.

Ordinarily these gypsyings began in the spring and ended when "roasting ears were ripe." Sometimes however a family did not return in the fall but remained away that winter, returning to Indianapolis the next fall. When a family remained away over winter it is probable that it was most often spent in some county poor asylum. The asylum records in various counties in Illinois and one record in Iowa show that some of these winter sojourns were in those poor houses and thus the worst of the winter was tided over.

In the early spring the Ishmaels and many of the other related families put all their worldly possessions in a hand cart and started across the country; later they were able to acquire an old broken down horse or mule, often a retired street car horse too old to use in that service, and a more dilapidated wagon in which to go on their wanderings. They would go often with several "wagons" in a party, sometimes alone. They camped in creek bottoms, near a settlement if possible, and lived off the country, begging and stealing. When they became tired of the place or, as often, were told to move on by the people who could no longer stand their depredations, they travelled on to the next place to do the same again. The residents along

these routes still remember the gypsies; though they can call few by name. There were some places on these routes where the gypsies particularly liked to stay. At the first approach of cold weather the wagons were turned toward Indianapolis and they hurried back so as to get located in the city before winter set in and as it has been expressed "to get their names on the trustee's books before frost appeared."

As whole families went together, old and young, parents and children, sometimes three generations at once, the tricks and habits of the road were passed on from one to the other. Several wagons would often travel together and gypsies would then meet other travellers and in this way matings between the gypsies took place. Propinquity and like mating to like were the two factors controlling the matings in these groups.

Another group of the Ishmaels were the so-called winter gypsies. This group, much smaller in numbers than the other, went south from Indianapolis into southern Indiana at the beginning of fall, in wagons, swapping horses, gambling and living as best they might. These people had no particular routes of travel; they simply went where they listed, returning to Indianapolis in the early spring. Many of the laborers in these families worked in the brick yards and so were unemployed during the winter. This winter gypsying did not continue long and does not seem to have been carried on regularly by those who did "winter gypsying." These families were of a slightly higher mental level than the summer gypsies.

Such is the picture roughly and briefly of the Tribe of Ishmael. The individuals in this large group of feeble-minded folk are continuing to mate like to like, and are reproducing their own kind. Some few branches of the Tribe have mated into better stocks, but these are so few that they are hardly noticeable. The few placed in orphans' homes and new environments have in some cases done better, but this has not changed the whole mass to any extent. The greater portion are still the cacogenic folk as found by McCulloch and are breeding true to the type. These germ plasms have now spread through the whole middle west and are continuing to spread the antisocial traits of their germ plasm with no check by society. The story of the Tribe of Ishmael is but another picture of the Kallikaks, the Nams and the Jukes.

HERITABLE FACTORS IN HUMAN FITNESS AND THEIR SOCIAL CONTROL

WILHELMINE E. KEY

Race Betterment Foundation, Battle Creek, Michigan

The foundations of national power are, in the last analysis, biological. We no longer look upon the life of a people as something unfolding itself in a manner wholly mysterious, and then as certainly going down to decadence and death. The growing clearness with which the progress of science enables us to view all life phenomena has thrown light upon human development in its physical, mental and moral aspects. Increasingly, we are being won to the view that the elements of a nation's strength lie in the inherent traits and tendencies of its people. Passing events, as they crystallize into history, are but the interplay between such traits and tendencies and various external influences, chiefly those expressed through the science and art of the period. Breeding from the best elements of the population brings a growing preponderance of those best fitted to take highest advantage of these influences. But science and art, in so far as they are not borrowed, are of themselves the abiding effect of this breeding from the best. Since their refinement of method too often encourages the survival of the unfit, the question of a nation's continuing integrity resolves itself into a nice balance between certain genetic and social forces which inhere in the blood lines of its constituent peoples.

The chief concern of the eugenicist is then the production of better human strains. This involves the physical problems of heredity as conceived by the geneticist. But vastly more it involves the social and moral reactions as conditioned by our physical and mental constitution in relation to the complicated organism known as the social order of today. We thus glimpse at the outset the complexity of our problem and the necessarily one-sided treatment which any brief study must give.

We none of us need to be told how complex is the thing we call human personality. Still most of us are aware of outstanding capacities and dominating tendencies in conduct. In the analysis which follows, certain capacities and tendencies of this kind were selected for intensive study and their occurrence noted from generation to generation in relation to types of

marriage which the individual was able to make. These capacities, notably, calculating ability, planfulness and perseverance were evaluated by means of the social test, that is the test of efficiency in the activities undertaken. Modern psychology has developed tests which, no doubt, are far superior to the social test. But in regard to these laboratory tests two things are to be observed. Their findings so far have coincided with the results of observation and experience on success in life, that is efficiency in activities undertaken. We are therefore justified more than ever in placing reliance on the social test, especially since it is obviously impracticable to apply the laboratory tests to all the members of the families we are studying.

Intensive study of such family networks shows widely differing potentiality of their various lines. In the Rufer Family, described at length in Carnegie Publication No. 296, five widely differing lines were discovered. This family was founded in the latter part of the eighteenth century by an able, industrious, plucky pioneer and his easygoing, amiable wife, who, it appears, was totally lacking in sense of number and proportion. Present day representatives of this family network show widely divergent social status. They spell their names differently and resent the implication of relationship. It was the custom of Aaron Rufer to count out every morning the potatoes needed for the family dinner; this done, his wife knew enough to put them over the fire, when the sun was high, and cook them till they were done. She neither spun nor wove, and the rest of her housekeeping was on a par with her cooking. There are many Mary Rufers to be found in disordered homes in a certain county of western Pennsylvania today. They are all descendants of Aaron and Mary in lines where marriage has consistently been into strains showing similar lack. In three of the lines, by contrast, there is conspicuous presence of planfulness, perseverance and ability with number; and here marriage has almost uniformly been into strains showing these abilities.

Lines C and D are particularly interesting. In line C there is complete absence in later generations of anything that might be called social inadequacy. It has realized the half-playful suggestion of a eugenicist of another age, that with proper selection (the right sort of marriage) a defect may be blotted out of a family just as "a careful gardener blots out the blemish from a flower." Line D, on the other hand, is replete with drunkards, prostitutes, petty thieves and paupers. When we go back far enough, we find this astonishing divergence arising as a very slight difference between two sons of Aaron and Mary. But the slight balance in favor of the better endowed son brought about marriage with a better woman who belonged to a strain superior to her husband's as well as superior to that of her

sister-in-law. Line E, founded by Aaron's imbecile son through his marriage to a sexually lax girl, for whom well-meaning neighbors wanted to find a home, has been persistently imbecile. Never but once in five generations, so far as could be determined, has there been fertile union with a member of a good family. This resulted in an illegitimate daughter whose two children are apparently normal. All the rest are mid-grade imbeciles, fortunately in the custodial care of the state. This extended experiment in mating then teaches the value of matings with good stock in establishing socially fit lines.

The study reveals too many of the social factors involved in the preservation of socially valuable traits. The mere possession of the traits in question, that is planfulness, perseverance and ability with number, has meant union with strains having similar abilities (assortative matings) while their absence has brought about union with individuals having the same or different defects, and this has operated to accentuate the condition of degeneracy and defect. Studies with the quantitative variation of these abilities point to a segregation of factors to produce on the one hand increase, on the other, progressive degeneration with reference to the traits in question according to the type of mating made.

Such findings attain grave significance when we consider the great fecundity of degenerating lines, their proneness to draw to themselves the weaker individuals of other mixed strains to form centres of degeneracy and defect. Every eugenic worker is familiar with such centres. The certainty with which they flourish in defiance of all attempts at amelioration, often because of such amelioration, emphasizes as one of the chief functions of our institutions for the care of the defective and diseased, a sufficiently detailed study of the family history of their patients to determine the blood lines from which they come. Only in this way can we give genetic potentiality its due weight in deciding the fate of such patients. Under present conditions of economic stress, the superintendents of these institutions are being urged to make the persons under their charge industrially efficient and insufficient appropriations for maintenance are adding their share to tip the balance toward the wrong side, that is in favor of early discharge and the almost certain marriage and multiplication of the unfit. When considering appropriations for this type of study we should always remember that as a people we cannot afford to do anything but spend all that is needed to cut off degenerating lines.

Again, public sentiment in many parts of our country is still so lax or uninformed that individuals belonging to many such tainted blood lines have not yet been committed to any institutions. With one exception, the

dozens of degenerates before described as belonging to line D of the Rufer family are all at large. Following them is like following the trail of the serpent. Inevitably they lead to the dregs of the community, or to knots of human derelicts, a moral menace and economic drag. The work within the institution should be supplemented by surveys, federally or state supported, and appropriate preventive measures taken.

Taking up a different phase of our question, we come to the abilities known as the aptitudes. These have also been shown to follow blood lines. If we study their occurrence in moderately gifted individuals, your family and mine, I am sure we can all easily be convinced of this. Moreover, these blood lines are found to move up or down in accordance with the type of marriage made. Peculiarities of reaction of what appears to be in the main a similar makeup placed in a varying or widely differing environment furnish interesting examples of the so-called greater effect of environment in determining social effectiveness. There is here a wide field. We must cease to debate the futile question of heredity versus the environment, and set ourselves to evaluating abilities, so far as we can, and analyzing the interplay of extraneous conditions on these innate capacities. The investigation of the social and economic misfits is peculiarly valuable. In this work, the physician, the teacher, the enlightened parent are showing a promising tendency to co-operate with the specialist in casting up the elements of a given situation. It would seem that here again there lurk certain dangers. One is the danger already touched on. That is that all these refinements will eventuate in the survival of the unadaptable or at least those difficult of adaptation. Our development should tend toward increasing power of self-adaptation. And, accordingly, should not these refinements of means be paralleled by a checking of reproduction when the difficulties of adaptation threaten to become too great? Checks in such cases might well be largely voluntary, self-imposed through eugenic education, as when a highly unstable individual, who is still able to carry his own weight, remains single in preference to marrying when marriage into a strain threatened to accentuate that instability.

Passing to the observation of assortative mating in yet other fields, we come to the production of those personalities which have given us our peculiar development in industry, science and art. These personalities have, through the study of their biographies and genealogies, been found to take their rise in the following manner. They have apparently arisen by the fortunate crossing of able lines in conjunction with a social or economic opportunity which favored the development and the play of their peculiar gifts. Sometimes, they even establish the favoring conditions instead of

waiting for opportunity to knock the proverbial single time. Occurring with such eminent individuals in the blood network are usually found many others having similar abilities, or at least occupations which suggest similar trait-complexes. The majority of these may indeed be more or less obscure, still we find here and there what might be termed concentrations of ability of various types. We find one line remaining tillers of the soil, others are given to merchandizing, while still others may show marked artistic trends. In the last-named cases, the artistic ability may "shade off" into a well-marked artizan group. Again we find a more or less well-marked altruistic bent for many generations, the latter as J. McKeen Cattall has shown evincing itself in one generation in the selection of the ministry, in the following, when preaching has lost some of its power and prestige, in preference for the career of teacher.

In the same way we find pioneering to be characteristic of many families, inventiveness in others, such as the Fairbanks, Herreshoff and Lake families, and executive ability a distinctive trait-complex in still others. Our history furnishes, too, many illustrations of signal ability in finance extending over three or four generations. In this connection, the names of Astor, Vanderbilt, Morgan, and Rockefeller will occur to all of you. It is true that the peculiar trait-combinations which make for this ability are different in the families we have mentioned, but in every case, the salient traits of the leading personalities find abundant representation in the network to which he belongs. Thus the story of our Americanism becomes the story of concentration of genetic potentialities of various kinds, fostered by favoring physical, social and economic conditions.

Extending our view to the field of statecraft, education and reform, we again find it to be the story of germ-plasms chosen through the exigencies of the place and time. Types of leadership as exemplified by the Beecher, Abbott, Lowell, Edwards and Adams families, to cite only a few of the many possible instances, have arisen in the same manner as that already outlined. Detailed analyses of such eminent men as Jefferson, John Adams, Benjamin Franklin have been made by the writer and the traits which contributed to the abilities in every case found to have abundant representation in other members of their families. Usually the peculiar trait-combination which each possessed has been found to occur but once. We have, however, in Theodore Roosevelt an instance where they appear to have occurred three times. Archibald Bulloch, his maternal great-grandfather, and Robert Barnwell Roosevelt, his father's brother are frequently cited as prototypes of this most illustrious "first American of his time."

In common with many great men, Roosevelt was inclined to minimize the

influence of heredity. He was proud of the fighting stock from which he sprang but beyond this gave little weight to ancestral factors. Time forbids the fascinating task of analyzing Roosevelt's character and family, the result of months of intensive study. Suffice it only to say that when we survey the concentration of gifts bestowed from both sides of Roosevelt's family, it seems almost inevitable that his course should have been what it was. Added to this we have the peculiar conditions, industrial, social and political playing their part in bringing out Roosevelt's salient traits. And furthermore, the characteristic moral and intellectual reactions of his family, were in him associated with a physiologic condition, present also in his father and others of his family which made it possible and even necessary to follow out every undertaking with the utmost intensity. What more natural than that in the political and industrial conditions presented by our country as a result of its phenomenal growth such a forthright, courageous nature as Roosevelt's, loving power and conflict, but loving the common people more, should find here a fertile field for the highest expression of its powers? It is this action and reaction between his restless, irresistible energy, playing with a wide range of intellectual tastes and powers and his sympathy with the fundamental tendencies of the American people that make of him such an outstanding example of the creative influence of a personality in our national life.

Hitherto the social and genetic process just outlined has appeared to take care of itself. There are, however, grave indications that a change is setting in. The dying out of many highly gifted lines and the low fecundity of others, which would, if producing larger families, increase their chance of producing gifted individuals are among the signs of this change. The salient economic and social factors involved in this grave situation have, most of them, still to be evaluated. We have already touched on several of them in the course of this talk. Among other means of correcting the anti-eugenic influences now at work to undermine our integrity as a people, we might name the following:

1. A return to saner and simpler standards of living such as will make possible the rearing of larger families in our "middle class." This would eventuate among other things, in a "back to the land" movement with all that that could entail for the well-being of the generations to come.

2. A campaign of education among all classes of our population which will foster the eugenic conscience. Many of our people, notably our young women, products of our so-called higher education, have been victims of the "ingrowing eugenic conscience." While undoubtedly the race has profited by the dying out of these rankest expressions of our rampart

individualism, in other cases, their failure to become parents has meant a distinct national loss.

3. The encouragement on the part of our numerous foundations, not of celibacy and comparative sterility in their members, but of marrying and rearing families having the desirable genetic potentialities. While this might result in some loss in the present generation, it would surely be compensated for in time to come. This brings us to another important factor.

4. The concept of service in contrast to that of personal aggrandizement. Our increasing socialization is bringing as a natural sequence such a conception of responsibility to the state and to humanity in the type of marriage made. This is the responsibility of maintaining through selective matings of the best available the highest possible level of ability in the family.

5. Early and more adequate economic adjustment to render possible early marriage and parenthood. Our hospitals and asylums are filled with the victims of maladjustment. A fair proportion of our delinquents are examples of maladjustment which might and should have been prevented. The writer has in mind a youth of fifteen who was admitted to a Training School for Feebleminded on a charge of incorrigibility. He had been a serious problem to his family since he came to them from Italy two years before. Had failed to get on at school, ran the streets, frequently climbing telephone poles and ranging about like wild, so that he was followed by a hooting crowd of boys who thought him crazy. Apprenticed to a tailor, he had continued his errant ways till the authorities could find no means of control but a school for the feebleminded. Here, fortunately, he found those who understood him, and, under their influence, he became gentlemanly, eager to learn and a general favorite among his teachers and mates. He showed marked ability in wood working, sang well and played the violin. Mental examination found him to possess adult mentality (his teachers had put him in a class of five-year-olds) and study of his family history revealed the springs of his abnormal conduct to be simply these: He came from a family which for generations had been artisans and small farmers; until he came to America, he had freely roamed his silent native hills. Is it any wonder that shut up in the confines of a tenement, in a narrow turbulent street, put into a school where all his excellences were ignored, his faults exaggerated, his efforts ridiculed he should have acted as he did? Removed to a sympathetic environment he made wonderful progress and is now supporting himself and his family at his chosen line of work, the making of furniture. Is it not a shameful commentary on our school system that this boy should have had to find his way into a training school for feebleminded before his peculiar abilities were discovered and fostered?

The least we can do is to apply mental tests to determine the mental level of all children in our schools. But at best, the mental test furnishes only what may be called a cross-section of the pupil's abilities at a given time. The results of these tests should be supplemented by family history studies to determine the trend of mental and emotional development. This is especially valuable in cases where the child or youth shows delinquent tendencies or bids fair to become an unusually brilliant student. In such cases, the ounce of proverbial prevention is trebly worth the pound of cure. How many of our young people, now irretrievably lost, might not so have been saved to become worthy and even able citizens? We want the survival of the self-adjusting; but we may well pause here to inquire whether our present social order is the one ideally fitted to encourage the adaptation and survival of the best. We can get along, in the writer's opinion, with less push, particularly when that is combined with unscrupulousness, and should work toward a condition where other and more ideal excellences abound. Our eugenic philosophy is as yet in its mere beginnings. These are only a few of the measures, which as good Americans we must compass if we would preserve lines of socially fit families and perform the desired service to national and racial growth.

A STUDY OF ONE HUNDRED AND FIFTY ADOLESCENT RUNAWAYS

ELIZABETH GREENE

Waverly House, New York City

The hereditary factors in crime have long been an interesting problem for eugenists. If such factors do exist, possibly the best place to study them will be in the adolescent delinquent, who is just beginning to show anti-social tendencies. It is these young offenders with whom the New York Probation and Protective Association does its work, girls who are just beginning to harass their parents and guardians with poor work habits and late hours, girls who have just entered into their first illicit sex experience, who have taken something from their employer, or more especially girls who have revolted against the discipline of home and have absented themselves without the consent of their parents, that is the so-called runaway girl.

It is this group which I want to bring to your attention, because it is the largest group which we handle, because it is a group with clearly marked inherited traits and one which is played upon by eugenic and disgenic forces. In thirteen months (May 1, 1920, to May 31, 1921) 150 runaway girls passed through our Mental Clinic. Some were found in the homes of friends old or recently acquired, some in railway stations, some in furnished rooms. Policemen, detectives, social workers brought them in. We studied them, planned for them and sent them home. Of the entire number, 51, or about one-third came from homes in the city. As many of these were persistent runaways and had remained undiscovered for long periods, we must consider them runaways, although the distance travelled was inconsiderable. The remaining 99 came from fifteen different states, more frequently, of course, from neighboring ones. Still, 7 came from Delaware, Maryland and the District, 8 from Ohio, 3 from Michigan, 1 from each Kentucky and Missouri.

The girls were all young, largely because running away is closely connected with the restlessness and dissatisfaction of youth. It is the curiosity and self-confidence of the girl of sixteen which brings her to the city, confident that she can take care of herself. The youngest whom we received

was only fourteen, while the largest group of all were the sixteen-year-olds. If we use the statistical device of the frequency table, we find that the first quartile falls in the seventeen-year-old group, and both the second and third quartiles in the eighteen-year-old group, showing that as far as age is concerned the group is fairly homogeneous.

When we consider the work histories of these girls we find that all but six had been employed, the exceptions being due to extreme youth. In fact, one little girl came to us from New Jersey with her school books under her arm. Sixty-one (or 41 per cent) of the girls were factory workers, thirty (or 20 per cent) clerical workers, twenty-four (or 16 per cent) domestics, sixteen (or 11 per cent) mercantile workers, while the remainder fell in small groups, telephone girls, dancing teachers, and show girls. They differ from the prostitute group in that there are fewer domestics and waitresses among them. There is probably nothing else particularly significant about this distribution. As adolescents they tend to find employment only in unskilled and uninteresting work; they become bored and run away.

The mental diagnoses were arrived at by means of a complete physical and psychiatric examination, as well as a mental test. Seventy-eight, or more than half of the girls, fall in the normal or full normal groups, about a sixth are borderline, and another sixth defective, the remainder being constitutional inferiors, psychotic and psychoneurotic. We find that runaways grade higher mentally than girls brought in for sex offenses.

The nativity of these girls is of especial interest. Twenty-two per cent were born in foreign countries and came to this country with their families. When we consider the nativity of the parents, we find that 57 per cent of these girls are the children of foreign-born parents, 28 per cent the children of native born parents and 13 per cent the children of mixed parentage. When we compare these figures with those in the 1910 census for women in New York state we find that a larger proportion of the runaway girls are the children of foreign parents than of the general female population. That is, they are the direct descendants of persons who themselves left home to better their conditions or see new places.

We have, therefore, 150 adolescents, all young, many the children of foreign born parents, trying to adjust themselves in work for which they have had no training, and to parents whose ideas are very different from theirs. The way out is to run away, although usually this is only attempted after frequent quarrels, and constant criticism. The act is in itself dependent not only on the social situation but also on the personality traits of the individual girls.

A few of them are no doubt typical wanderers, such as Dr. Charles Davenport has described. A little girl who suggested this type was an Italian who was brought to us after her third absence from home. The parents were immigrants, while the maternal grandfather had left Italy for South America as a young man. A little better example was a girl who had been placed by the Juvenile Court as maid in a Connecticut city. She had very little amusement and one day when her mistress left her to get lunch and wash a tub-full of clothes she ran away to New York. Her family history would delight any eugenic field worker. Both parents and a maternal aunt were alcoholic, while an older sister had been committed to a school for girls in Connecticut. Moreover, the family proved to be well-known, both in Utica and Hartford, as wanderers; both parents were peddlers, while the uncles were horse traders and troubadours, their sisters and wives wandering with them.

Besides wanderlust we find in these runaway individuals the native push and energy which mark the hyperkinetic. Others show an entire lack of these qualities and are the so-called inadequates. That these two types may do the same thing from quite different motives was shown in three runaways who came in May. These little girls, the oldest seventeen, were idling in the square of a New England town when an interurban furniture truck stopped and the drivers offered them a ride. One, a round-faced, Anglo-Saxon, who had already lived in three New England states, accepted readily. She was delighted with the chance to see New York. The second girl, a moron, whose father is an epileptic and whose family is "on the town," accepted because she had not the intelligence to decline. The third left home because her alcoholic father was so "distant and dark" when sober.

In concluding we might say that one of the social problems of the adolescent is her tendency to run away. Runaways are always present in large cities, in stations, dance halls, and boarding homes. They show a distinctly American tendency to manage their own affairs at an early age and an adolescent dissatisfaction with their homes and revolt against parental authority. As the children of immigrants they are tied to no community by the associations of generations, through faulty Americanization they have lost touch with their own parents. Most fundamental of all, however, are the inherited traits which furnish the push and energy for journeys and the Wanderlust which makes them second nature.

MATE SELECTION

ROSWELL H. JOHNSON

University of Pittsburgh, Pittsburgh, Pennsylvania

Mate selection or sexual selection as it was designated by Darwin is best defined as the production of racial change resulting from an hereditary difference between the mated and the unmated, or a correlation between mates. The subject does not lend itself to classification wholly by direct division and subdivision, but is better classified independently on the basis of various criteria. One instance may then come under several heads of such a classification. The following plan is proposed.

$$\text{Classified as to correlation}\begin{cases}\text{Optimal}\begin{cases}\text{Periodic}\\ \text{Secular}\end{cases}\\ \text{Assortative}\end{cases}$$

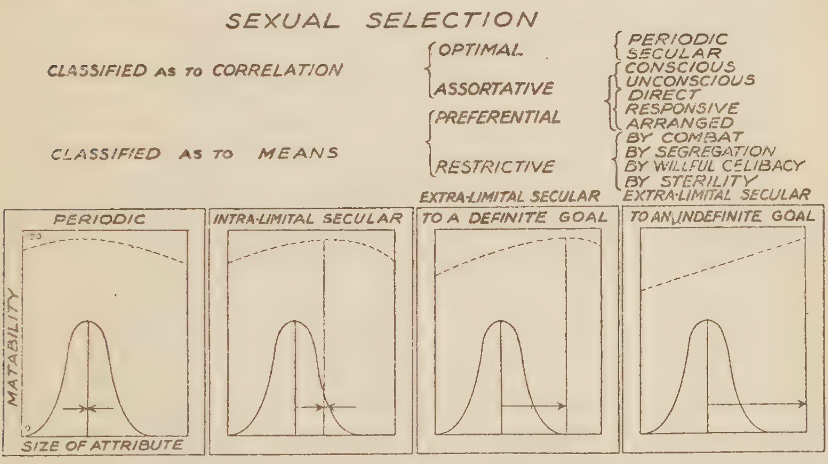
In assortative mating the phenomenon of interest is that likes tend to mate with likes. This has the effect, even where all the individuals mate, of accentuating attributes and so increasing the variation of the species as a whole, as compared with what would be the result if mating were wholly at random. The existence of assortative mating in man is quite evident, most particularly between those of musical interests, although needed comparative statistical studies are as yet lacking. Its effect is fortunate for it has accentuated high attainments in certain lines, and in cases where the characteristics are undesirable, they have been concentrated in fewer cases more readily located and dealt with.

In optimal mating, selection of mates is more frequent from those possessing a certain degree, or the nearest approach thereto, of some attribute with the result that the species in the course of many generations is brought to that degree of that attribute. If this favored degree is at the mode of the species then there is no evolutional effect, the effect being merely to hold the species at this optimum. This has been called periodic by Pearson. If the optimum lies on one side of the mode, then the species is led in that direction and the selection is secular, in Pearson's language. The race may thus be carried to an optimum within the range of variation then existing, to one

outside the range or indefinitely, when the optimum is either the minimum or maximum possible and lies outside the range.

- Classified as to means
  - Preferential
    - Conscious
    - Unconscious
    - Direct
    - Responsive
    - Arranged
  - Restrictive
    - By differential death rate of the sexes
    - By geographical and social segregation
    - By willful celibacy
    - By sterility
    - By retarded marriage

In preferential selection there is a higher mating rate at the optimal degree, because there is a direct preference for such individuals as mates.



In restrictive selection there is no direct preference but a corresponding result is brought about by the fact that by some means the range of choice is so restricted or controlled that irrespective of preference, sexual selection takes place. One means is by differential death rate of the sexes. A well known example of this means is in the head hunters of Borneo where fighting between the males reduces their number selectively on the basis of fighting efficiency. Properly this belongs under lethal selection, but as a borderland category, it is included here. Another example would be the segregation of individuals of differing sorts in different places because of the location of

industries, racial distribution and the like, coupled with a varying ratio of sex to sex in different places. The conditions which produce a shortage of one sex will ordinarily do so in a selective way, so that the make-up of the population of that sex shows a different average of the attributes in question than if it equalled in numbers the opposite sex.

Preferential selection may be conscious or unconsicous. By conscious selection is meant direct conscious discrimination. By unconscious is meant those cases where preference results from a competition in the attractiveness of potential mates in which the selector simply feels more "drawn" by one individual than by another without any analysis of the elements. The two processes may be mixed and there is doubtless a twilight zone.

During the course of courtship there is a change. At first preference is more purely a matter of weighing of attributes, but as the emotions become more and more involved, the analysis of attributes is so dulled as to give such truth as does apply to the old statement that "Love is blind." As a result the process as a whole is by no means devoid of conscious discriminative preference.

Mate selection is "responsive" when an individual of one sex is stimulated to greater attractiveness in the presence of one individual of the opposite sex than before others. That this stimulation is in some cases in part manifested by increase of pulse is responsible for the conventional association of the heart with love. It is here that the woman has a more active rôle in courtship than is usually supposed. By responding more effectively to a certain man, this man is in time drawn to her more than others who do not evoke either her unconscious stimulation or effort to be attractive. This then on the part of the selected may be unconscious or planned.

Preferential selection is "direct" when the mate prefers one over another candidate. It is here distinguished as "arranged" when the preference, whether conscious or unconscious, is by the parents, guardian, or friends, or even a broker. These may arrange the match directly or arrange to bring into acquaintanceship under propitious conditions the individuals whom it is desired to mate.

The elements of preference are not all of equal desirability racially nor of equal interest eugenically. Some eugenists have shown greater concern over physical characteristics. This is not shared by the writer because with all possible humanitarian mitigation, lethal selection is still sufficiently active to prevent serious physical retrogression. On the contrary, to eugenics alone can we look for salvation from a serious decline in the mental and moral attributes of the race.

The rôle of physical attractiveness in sexual selection is of paramount effectiveness. In pointing this out, Knight Dunlap has gone further and expressed satisfaction that beauty is the leading element in mate selection. Beauty, however, embraces two classes of elements toward which our attitude must differ. In so far as good color, clear skin and normal weight for the size in both sexes and adequate width of pelvis in women produces beauty it need not be begrudged its effectiveness. But in reality such elements of beauty are quite common and contribute only a small part of the effective ensemble. The other elements, while of great effectiveness, especially in selection of women, are mainly merely details of facial shape and that distribution of adipose tissue most in vogue at the time. The great effectiveness of these feminine elements so stimulate a man that he neglects to allow, on the average, a proper weight for elements which vastly transcend them in importance. Therefore sharp issue is here taken with Dunlap in his contention that beauty consists mainly of items of important racial value and therefore should properly be the leading element in mate selection.

Those mental traits that are most stimulating are the most effective. Hence vivacity leads. Doubtless the selection for vivacity was useful, but it may easily have gone too far in some strains. It is by no means a measure of mental efficiency and is frequently associated in its higher degrees with instability and hyperthyroidism. Indeed it seems probable that much of the instability, neurasthenia and mental disease of today is the result of the relative over-effectiveness of vivacity in mate selection. Luckily in the selection of males vivacity yields more to a consideration of the fitness of the man as a steady provider.

On the other hand, the non-stimulating qualities—stability, persistence, endurance, poise and judgment are undervalued traits. The young man especially, as he, more than the young woman, is too susceptible to mere physical charm, should be on his guard against the under-valuation of these traits. For every slight advantage in beauty and vivacity he obtains in his mate he is, on the average, foregoing a much larger degree of important excellences in other lines which are less stimulating.

It is commonly alleged that men prefer to marry women of intellectual capacity inferior to themselves in order that their feeling of leadership may not suffer. This in my opinion is incorrect in the long-run, because mental alertness, fortunately, unlike some other mental attributes mentioned, does have a stimulating effect and hence is effective without the necessity of conscious preference.

Public record of the high scores in the systematic mental testing now

becoming common would probably have a decided value in making more evident mental differences now hard to discriminate and recognized within too narrow a circle of acquaintances.

The accomplishment of the sought and the accomplishment and longevity of ancestors, uncles, aunts, brothers and sisters may also well influence one's judgment in mate-selection.

It is the fashion to decry the influence of family and wealth upon mate selection and of course the individual herself or himself should be the main consideration. There is, however, some degree of positive correlation between social and financial status and the directly desirable qualities, so that we may be less concerned with these less personal qualities than by the over-emphasis of mere physical attractiveness.

Repute in men, and to a less degree in women, is of high selective value and has enough correlation with desirable attributes to be of real eugenic value. Since the standards of desirability and the relative rank in repute of various attributes are subject to change, it is of moment to the eugenist to inquire into the causes of these changes. In general there is a competition between the groups superior in each of several traits who wish their particular excellence to contribute as important an element of repute as possible. This conflict goes on between those who glory in their birth either in the nobility or in an "old family," those who wish appreciation of their wealth, and a third group of "intellectuals" not included in the other two groups. This last is sometimes subdivided into artistic, literary, scientific and "public spirited" groups and even into subdivisions of these. Each group yearns to be relatively highly appreciated. The repute accorded to these elements varies with time and place and is ever in a state of flux. Parallel with this "struggle" between groups of superiors is another effective between the superior and the mediocre, who decry, either directly or more usually by imputation, generally unfair, of some questionable quality such as snob, high-brow, big-head, "aristocrat," blue stocking, swell, "high and mighty," pedant, "holier than thou," googoo, and the like.

These phenomena are more easily examined in undergraduate life, especially that of the interesting effort of mediocrity to avoid recognizing excellence. We have the mediocre students calling those who lead in class "greasy grinds." At Dartmouth the epithet "wet" probably from the wet towel around the head originally synonymous with "greasy grind" has been extended to deride any brilliant student. One reason for the derogation of mental excellence is to permit a relatively higher repute for athletic prowess and for "camaraderie," but it is largely an attitude of the mediocre for their own protection.

Since the majority are relatively mediocre and are all seeking solacing thoughts, the idea of underestimating the excellence of the superior will always be of great seductiveness. This makes more difficult the upholding of the best standards of preference in mate selection.

Yet at different times and places society has shown itself capable of disproportionately high productiveness in one field of activity or another. This has been partly the result of the varying distribution of man's approval of the different attributes for a greater share of repute. Thus oratory and athletics in Greece, military prowess in Rome, and the arts in the Italian Renaissance, and later scholarship and research in Germany and wealth in the United States hold in succession places higher in man's esteem than had been the case. The significance for mate selection lies in the relative rank of the various elements of repute of the time and place under consideration and here social progress and racial progress are nearly hand in hand, for an excellent distribution of the elements of repute favors each. Indeed the best distribution for one is nearly the best for the other.

One divergence only arises. One commonly hears it said that some specially gifted individual might accomplish more for immediate social progress if childless or possibly even if celibate. This has led a few "feminists" to protest against the dictum of the eugenists that all superior persons should adequately reproduce. At this point the eugenist appeals confidently and urgently for the ultimate benefit of the species. This is best attained, in the long run, by the adequate reproduction of even the specially gifted; for their superior germ plasm will thus yield in the future proportionately greater social and intellectual contributions. This is because the long succession of persons produced from that chain of germ plasm will make a greater social contribution than that possible by the one life because of its celibacy with a resultant destruction of valuable germ plasm.

A unique feature of preferential mate selection has arisen in recent years by the introduction to our species of the method of artificial impregnation now well known and not infrequently practiced in the case of horses. The author is reliably informed that in one of the largest American cities many women whose husbands are sterile now resort to a certain physician who inseminates them artificially. As is natural, these women stipulate the race of the father whose identity they rarely know. In some cases they are further concerned with his quality and attributes. It is obvious that this physician has a very heavy responsibility in thus determining the quality of many of these offspring. If he will, he can render a very valuable eugenic service by declining to inseminate inferior women and by obtaining the best fathers possible.

Writers on mate selection have usually assumed that rectification and intensification of standards of preference are the sole objectives of eugenists in this field. This error arises from too intent a concentration on the analogy of lower animals. In man especially in recent years willful celibacy and childless matings have become relatively important elements.

Celibacy has varied in its causes with the years. Formerly it was mainly religious and such celibacy still persists, although it is, I believe, on the wane. Such celibacy has cut off two groups from parenthood. One was inferior because it contained those actuated merely by a desire for the protection and physical inactivity afforded religious celibates and their easy life. The other group was superior because for a long period, and still to some extent, it has been composed mainly of the brightest and most idealistic boys in a family who were led to train for the priesthood.

Once the churches now having the priestly celibacy realize how the success of their own cult is reduced by breeding away from the qualities they desire, its abandonment will command an ever growing sentiment.

But it is the newer celibacy that is more distressing—that evidenced by the low marriage rate of many superior women. The evidence concerning woman college graduates has been easy to obtain and these may be taken to represent the group. In their low marriage rate we apparently have the joint result of two unfortunate difficulties—first, the under-valuation of mental ability and the over-valuation of mere physical attractiveness by men as elsewhere decried. Nearly as important is the inefficient standard on the part of these women by which they respond only to potential candidates whose qualifications are made so high as to render their number so greatly restricted that the chance of marriage is seriously reduced. Mathematically we may express it as follows. A woman who ranks thirteen where one is the most superior and one hundred the most inferior, who feels no mating interest in any man less than rank six reduces her chances of marriage to less than one-half and therefore acts dysgenically. Theoretically such a woman while young may well have an excessively high standard, but as her mating years pass, her standard should step by step slacken so that she will marry eventually, provided only that the average quality of her mate is not actually so inferior as to make the average of the couple below mediocrity. In other words, a superior woman today needs to be more concerned with marrying and less with her standard of preference; unusual as that sounds from a eugenist.

Direct admonition is of course relatively unimportant in modifying customs, so it behooves us to examine the conditions prevailing to see if any of these are being modified or are modifiable. Some of the causes of this low marriage rate are:

1. Isolation of sexes by separation in their schools, organizations such as Y. M. C. A. and Y. W. C. A. and even social clubs.

2. Segregation in their work largely with women and married men.

3. Limitation of proper avenues for widening acquaintance, on the one hand in small towns and on the other in the large city. The war Community Service did a great deal to bridge this difficulty temporarily and some of its work has left permanently surviving institutions and customs.

Passing to a consideration of restrictive marriage, several elements which reduce the number of effective mates require consideration.

1. Incontinent celibacy.
2. Inherent sterility.
3. Sterility the result of disease.
4. Induced sterility.
5. Prevention of conception.
6. Retarded marriage.

The incontinent celibate is usually the parent of few or no surviving children. This may be due to infection, sterility of the temporary mate, greater efforts to prevent conception, or in case of conception, greater readiness to abort. Furthermore, offspring of such a union are often still born, or die prematurely because of syphilitic infection, so that concern with this class from a eugenic standpoint is mainly to keep superior young persons from finding their way into it. With the improvement of the prophylaxis and treatment of the venereal diseases, births will become more common from this group of incontinent celibates because sterility will be decreased. Such a condition will demand more rigorous attention to a feasible program of restrictive eugenics.

Unfortunately, many otherwise desirable individuals are inherently sterile, nevertheless it is probable that on the whole there are more inferior than superior individuals in this group. Sterility unknown to the other mate at the time of marriage should be a proper ground for divorce for those who desire it. Sterility the result of disease may be classified into that resulting from venereal diseases and that from other causes. The latter may be passed as relatively unimportant.

This former group may be divided into those individuals infected as the result of their own moral transgression and those innocently infected by nonsexual contacts or by infected mates.

Those infected as a result of moral transgression will average inferior, to judge from the nature of the inmates of genito-urinary wards of hospitals as compared with the other wards, as I am informed by Captain Paul Popenoe

from his experiences in army hospitals. Venereal infection is particularly important in holding down the spread of some inferior races that would otherwise be very fecund. Should the venereal diseases ever be effectively treated or prevented, it would be very important that means of birth control be diligently spread among the married couples of such races.

As to those innocently infected, one concludes that they average inferior, from what is known of assortative mating.

This class of sterility then on the whole is eugenic in its selectional effect.

Permanent sterility without impairment of sexual functions can be produced in each sex by operation and by other means and has been so produced voluntarily by a few to permit more sexual freedom. Some eugenists have been concerned lest this practice might become so common as to endanger the birth rate.

But since the sterilized, as a whole, would average decidedly inferior, at least in some important attributes and since the general birth rate could well stand some diminution, this practice does not at present seem inimical to race progress.

It has been argued that a wider knowledge of the prevention of conception will too generally result in childless or inadequate families among the superiors. The passing of laws against the dissemination of such knowledge is not the way to meet this difficulty, for such knowledge, long since common property in Europe, has already reached, in general, the superior group in American cities. Such knowledge is of such great eugenic usefulness when once thoroughly widespread that the suppression policy should be abandoned, even though for a time population might cease to increase. Our effort in this connection should be made to distribute its application on a eugenic basis.

Since a retarded marriage often reduces the number of progeny and always lowers the rate of increase per century, the effectiveness of such matings is decreased and it may be considered under this head of restricted sexual selection. Evolution is produced if among the mated there is an inheritable difference between those of early or normal mating time and those of retarded mating time. Such evolution is of course in the direction away from the attributes of the retarded unless counteracted by lethal or fecundal selection.

The late married certainly do differ from other mates and the applied eugenist is concerned because one important group of the late married result from prolonged full time education, especially in the medical profession. We may therefore well plead for (a) more part time education in pro-

portion to the full time education in those of marriageable age, (b) a restriction of the requirement of full time medical students to two years of college before their five years of medical study, (c) laws prohibiting marriage under eighteen to help correct the balance from the other end.

The leading conclusion of this paper as it affects applied eugenics is "Select the best available as to the most important attributes." To this older well known maxim we now must add a second "All superiors should mate."

DISCUSSIONS OF PAPERS READ AT THE CONGRESS

SEX DETERMINATION IN ROTIFERS

A. F. Shull

George H. Shull: I would like to suggest that there is no *necessary* inconsistency between the cases so often demonstrated in the rotifers, in which sex has appeared to rest upon some condition of the environment, as nutrition for example, and these new cases in which it seems to be traceable to the events which take place at the period of meiosis; for if we assume that in all these cases the *proximal* cause is an environmental (nutritional?) one, it is only necessary to recognize that the chromosome constitution is one of the necessary elements entering into the production of various enzymes or other chemical substances and that difference of constitution between two members of one pair of chromosomes may result in just the difference in enzymes or other chemical substances, which is effective in determining the development of the one sex instead of the other.

It should also be noted that the failure to discover a difference in chromosome number in the two sexes is not proof that the difference between the sexes is not based on chromosome differences, for in many other species there is no differences in *number* of chromosomes in the two sexes, since the one sex carries an XX pair while the other has a corresponding XY pair.

CONTROL OF SEX IN CLADOCERA

A. M. Banta and L. A. Brown

A. F. Shull: It may be possible to explain the relatively smaller effect of greater crowding than of less crowding by work on rotifers which shows similar results. The concentration of the excretory products would be proportional to the number of individuals. Now, in rotifers, in which the effects of a long list of chemical substances upon the life cycle have been tested, it was several times shown that a strong solution of a given substance produced a smaller visible effect than did a weak solution of the same substance. It would not be surprising, therefore, to find that great crowding of Cladocera modifies the life cycle in some respects less than less crowding does.

Major Darwin: Has the direct bearing of this subject on eugenics been considered? Guinea pigs and rats under crowded conditions breed freely, and under uncrowded conditions do not breed so well. Crowding can affect sexual reproduction. This material may have a bearing on eugenics, as an explanation of the effect of crowding in slums.

Dr. Banta: I have not considered the eugenical bearing. This might not apply. Certain specific cultural media also lead to the production of males.

E. G. Conklin: Many rotifers living under conditions which, humanly speaking, would be considered bad, reproduce freely. Those living under good conditions sometimes produce no males. Phyllodena roseola have been kept under the best conditions and have gradually ceased reproduction and the females become entirely sterile. Occasionally the water dried up and they underwent encystment, and when they were soaked again, the females immediately began to reproduce actively. This might have eugenical bearing considering what we in America are undergoing now.

LINKAGE WITH LETHAL FACTORS, THE SOLUTION OF THE OENOTHERA PROBLEM

George H. Shull

R. Ruggles Gates: I would like to ask what was the source of *rubricalyx* used. I have used *rubricalyx* in my experiments and have gotten an entirely different set of results.

Dr. Shull: I made the crosses discussed in this paper with material from Sutton and Sons, Reading, England, to whom Dr. Gates sold his purebred stock of this species. The source of material is wholly immaterial, however, in experiments such as I have been conducting in the Oenotheras for a number of years, for I have been dealing with *rubricalyx*, *primarily as a unit factor, only incidentally as a taxonomic unit.*

Dr. Gates: In my experiments I used the original *rubricalyx*. The *rubricalyx* which I sold to Sutton has not remained pure. I have had occasion more recently to test Sutton's material of this species, and I found that it showed evidence of crossing with some other species. In 1914 I published a complete account of the F_2 and F_3 generation, so I am familiar with the behavior of this species and able to identify hybrid conditions.

INHERITANCE OF MENTAL DISORDERS

A. J. Rosanoff

Stewart Paton: There are a great many difficulties which the alienist has to meet in dealing with the problems of heredity, and I was greatly pleased in Dr. Rosanoff's paper that he was so conservative in drawing definite conclusions. Mental disorders are much more complicated than the casual observer believes them to be.

A mental disorder is a more complex disorder than a maladjustment at the psychological level. It is an imperfect adjustment of the whole organism. The average lay person believes that insanity is a disease of the brain, but it is a disease of the entire organism. We have been so accustomed in recent years to follow Hughlings Jackson and speak of levels of activity, that we have begun to think of different levels of insanity. Insanity is the way that the entire organism reacts to a difficult situation. The final test of sanity or insanity is what the person does.

THE GENETIC SIGNIFICANCE OF THE ALCOHOLIC TREATMENT OF WHITE RATS

E. C. MacDowell

A SUMMARY OF THE EFFECTS OF EXCESSIVE ALCOHOL TREATMENT ON HEREDITY AND DEVELOPMENT IN MAMMALS

C. R. Stockard

E. M. East: It seems to me that another point might be brought up. These experiments are, in general, made with alcohol because it has been known for a long time that excessive alcoholism does effect the organism. We could use other materials and get effects. To any one with a knowledge of chemistry it is not necessary to conclude that anything like the same effects could be found with the use of the same quantities of another material. It is worth while noting that the use of a small quantity might have one effect and that of a larger quantity a different effect and a conclusion ought not to be drawn, as Dr. Stockard has said, by the sociological press as to the effects of a similar use of alcohol by human beings.

J. Arthur Harris: There is a possibility of an advance in the analysis. Dr. Stockard has called attention to a real difference in the death rate in the two groups of animals. There should be associated with that a very great difference in the variability of the offspring. Has Dr. Stockard made a study of the offspring in the cases where the mortality is high or especially low?

Dr. Stockard: There is not a great variability.

G. H. Shull: It is not quite clear to me that Dr. Harris' point is well taken at this time. It seems to me that if there is a considerable variation due to this condition under which the organisms have developed there might be increased instead of decreased death rate. It seems to refer any variability back to internal constitution and leaves nothing for the environment that has been introduced into the experiment. In some of them there are more favorable conditions enjoyed than there would be under normal conditions and such conditions would serve to decrease rather than to increase the death rate.

Lucien Howe: I want to give a word of appreciation for the work of these men.

Raymond Pearl (chairman): Is there further discussion? If I might be permitted from the chair I should like to say just a word on this myself, because some years ago I did some work on alcohol, and I have been very much interested in the work which Dr. Stockard is doing. I think that any difference between Dr. Stockard and myself that there has been is a difference in emphasis. Alcohol unquestionably has a selective action upon germ cells. I got, finally, a race of chickens that any poultryman would call a race highly superior to normal chickens. Those that were defective were eliminated, and so far as the race was concerned, have no consequences for the future. I wish to make it clear that I am not criticizing Dr. Stockard's results. I have the greatest admiration for the intelligence and scientific acumen with which he has done his work. I am really trying to emphasize another point of view which just as much deserves emphasis. I thank you for letting me enter the discussion from the chair.

Dr. MacDowell: Why was not the selective effect of alcohol immediately apparent in the guinea pigs, if this action of the alcohol accounts for the condition of the fourth generation? In the experiments with rats the number of litters produced by the rats actually treated was 60 per cent smaller than that produced by the brothers and sisters in the same period, while the untreated descendants of the treated rats produced in the next generation from 30 to 50 per cent more litters than the controls. Another point that the rats bring out very clearly is that controls in one generation do not serve as controls in another generation. I believe personally so far as this point is concerned that the results that Stockard's work bring out are very valuable but this is a point that must be brought to mind.

Dr. Pearl (chairman): Before we disperse, I should like to call your attention to the fact that there are other Sections in operation in the West Assembly Room in the Hall of the Age of Man.

I should like to say just one thing, if I may, in closing. I think it may be proper for me to say it, since the present Chairman had nothing whatever to do with the arrangement of the program or with the planning of the program. I think all Geneticists will agree, and all that I have talked with have agreed, that we have had a very remarkable program in Genetics here, and that it has marked many advances in our knowledge of Genetics, and that it gives the impression that Genetics is moving rapidly in this country.

I am sure that I voice the sentiment of all interested in Genetics, and all those who have been members of the audience here when I say that we thank the Secretary of the Section of Human and Comparative Heredity, Dr. Helen Dean King, for arranging such a wonderful program for us.

INTERMARRIAGE OF BLOOD RELATIVES IN THREE OLD NEW ENGLAND COMMUNITIES

Ruth Moxcey Martin

R. H. Johnson: There is an old saying "Blood will tell." The difficulty is to say what blood will tell. Although there were these few families, doubtless if there were discrimination against all cousin marriages, the town and family would have given us a better future.

Dr. Davenport: There is no question which is more commonly asked of the Eugenics Record Office than that concerning cousin marriages. We receive a good many inquiries about proposed matings, and I presume that in over half of these cases, these inquiries have been made because of a proposed cousin marriage, and the inquiry has been urged by the families of the young people because such a marriage has in the past proved unfortunate in the family. We always respond that it is impossible to lay down any general rule, that it is necessary to know the family connections, and especially the traits of the common blood. We can only point out instances like those which have been so well described by the last speaker, where the presence of degeneration or obvious defect of the common blood is sure to reappear in the offspring of a cousin marriage. But if, on the other hand, there is no obvious defect in recent generations in the close cousins of the blood considered, then we have no reason to expect defects in the offspring. On the

contrary the mating may be regarded as a eugenic one, and we have occasion to call attention to instances of cousin marriage which have produced only uniformly good progeny. We have often used the example of Charles Darwin who married his first cousin and who produced such a family of illustrious sons and daughters.

THE LEARNED BLACKSMITH

H. J. Banker

Wilhelmine Key: I want to say just a word. I think we are peculiarly indebted to Dr. Banker for this exceedingly careful and detailed study that he has made and for the cautious conclusions to which he has been led, because I think genealogists as a whole are frequently criticized for leaping at conclusions, and we have in Dr. Banker's paper an example by which we may all profit.

In this connection, I should like to say too, that any student of genealogy finds abundant examples of the type that Dr. Banker has brought before you this morning, that is, a concentration in a given personality of gifts which characterized many of the more obscure members of the network to which he belongs. Frequently too, we meet in the biographies of our eminent men a disinclination to ascribe to ancestral influence abilities which might otherwise be regarded as the product of their own striving.

As an example of this we may cite the late Theodore Roosevelt. He always said that he came from good fighting stock, but beyond this, he was inclined to give scant weight to heredity as a factor in his course of development. However, if you go back to Theodore Roosevelt's ancestors, you find abundant occurrence of the traits that made for his excellences, to name only a few, we find a love of nature and a love of truth, fearlessness and a dauntlessness that made them stand for what was right and worth while, and literary ability of a high order. Not only do we find such traits as these, but we find on, both the maternal and the paternal side their combination in a personality that might stand as a prototype of Roosevelt himself.

On the maternal side there was Archibald Bulloch, who was his great grandfather. He was governor of Georgia in Revolutionary times and espoused the patriot cause when scarcely any of his associates did, pursuing a course that was notable for its courage and independence.

On the paternal side we find Robert Barnwell Roosevelt who was his father's brother. He was a New Yorker, established the New York Fish Commission and for twenty years served as Fish Commissioner without pay. He wrote books on the fishes and game birds of North America. You know how strong those tastes were in Theodore Roosevelt. He was, moreover, an ardent reformer, and edited a paper which was opposed to the Tweed ring; elected to Congress, refused to obey his party's behest. In his leisure hours, he wrote poetry and stories that show a decided mellowness and play of human feeling. I think he had a mellowness and geniality which you did not quite get in his nephew.

Roosevelt's remarkable development appears to have come through the possession of these salient temperamental and intellectual traits associated with a physiologic condition where everything he undertook had to be done with all his might and main. This condition was also characteristic of other members of his family. Then Roosevelt came into public life when his dominant traits of fearlessness and rebellion against domination by a party were becoming a large part of national feeling. We get here an action and reaction between individual tendency and social and economic conditions, with success and applause which serve to encourage and intensify the individual tendency. This constitutes leadership in a critical time in national history.

SOME FAMILIES AS FACTORS IN ANTI-SOCIAL CONDITIONS

AMOS W. BUTLER

EDWARD WALLACE LEE: This paper is a most valuable contribution. Feeble-mindedness, so far as I can observe, is increasing. When we recognize this condition and recognize that it is increasing, what is the remedy for us?

This is the great problem that concerns all who are interested in these conditions. For some thirty years I have been interested in this subject and have had an opportunity to study these cases and where indicated have resorted to castrating to prevent the propagation of this class of individuals, and those that I have treated were thus prevented from becoming a menace to the community.

Another factor in this condition that is not receiving the attention it should, especially from the medical profession, is, that the physical condition of the feeble-minded is not given sufficient attention. There may be a condition of the mind that is not dependent upon the body, but I doubt it, at least, I cannot imagine it. I cannot imagine a defective mind unless there is a physical defect existing somewhere either in the brain itself or in some other portion of the body. I know that a diseased or mal-functioning intestinal tract will produce a condition which might be called feeble-mindedness—at least it disturbs the mentality. The thyroids and other ductless glands when not properly functioning may produce the same deleterious effect on the mind.

These feeble-minded people are not given the physical attention that their condition demands. Criminals are not given the physical attention that their condition demands. They may be considered and be pronounced feeble-minded; their minds may have been examined; psychological examinations may have been made, but their bodies have not been given the attention that they should honestly and scientifically receive.

THE TRIBE OF ISHMAEL—A STUDY IN CACOGENICS

ARTHUR ESTABROOK

DR. PATON: Do the symptoms characteristic of the maniac depressive type of personality or the schizophrenic type seem to be responsible for the behavior of any of the cases that you have reported?

DR. ESTABROOK: There has been practically no insanity in the Ishmael family. The little that has appeared has been largely due to syphilis. The characteristic mental status of the Tribe has been that of a high grade feeble-mindedness.

DR. PATON: I should like to ask whether there was any detailed physical examination. Might it not be possible to correlate some of the results of the physical examination with their mental traits?

In the aviator one of the signs of physical unfitness for work was loss of interest in the work. Dr. Mac Lake in handling four thousand cases among the aviators found that the loss of interest in the work was often closely correlated with the change of the dermatographic reaction on the skin.

Possibly these vagrant types of personality might show interesting correlations of physical and mental symptoms.

Dr. Estabrook: I should say in answer to Dr. Paton that this type of vagrant personality has been observed and studied physically in but very few cases. From the standpoint of physical examinations, it has been possible to get clear, good, physical examination of but few persons, those that have been in institutions, or those who for some reason or other it has been possible to bring to some sort of a clinic. This study has not gone into the finer discriminations because of the magnitude of the problem.

The Ishmaels are found in ten states and number about fifteen thousand individuals, and it has been possible to get only the roughest data concerning the more or less pronounced traits.

Franklin H. Giddings: Has anything been done to prevent the increase of the tribe?

Dr. Estabrook: From the standpoint of the Record Office, this study has been purely academic. From the standpoint of what can be done to prevent increase, I might say that some data from the Record Office have been placed in the hands of the Board of State Charities in Indiana and other states; it has been given to charity organization societies, to different state institutions, and these other workers have done what they can to take care of these feeble-minded situations and to see that those that can be placed in institutions are so placed. From the standpoint of prevention of increase, I think the present problem is the placing of the information before the public, thus enabling them to take care of these defectives properly and with an intelligent understanding of the problems they are attempting to solve.

It is not the function of the Record Office to carry on any definite propaganda. Its function is purely academic.

Dr. Lee: Did you report on the whole tribe or just select individuals of that tribe? I was wondering if there are any good Ishmaels.

Dr. Estabrook: In the last decade or two there are a few good Ishmaelites. I think, of the whole group, approximately two or three per cent might be classed as average persons, socially and intellectually, and when I use the term average, I am using it according to the standard worked out by the United States Army in its classification of draft quotas. I can think of but two or three individuals who have become what we would call exceptionally good individuals, socially adequate, from among the Ishmaels.

About 90 per cent of the total group, and even more, are what we would call socially inadequate. The Ishmaels have been more or less under the public eye to a certain extent for about forty years, especially in the cities, and we do not find many among them who reached the so-called average class.

Prof. Giddings: Can you tell us in a word how it became possible to get a piece of scientific work of that character and extent done in state political institutions of today?

Dr. Estabrook: My association with state institutions and state boards has been entirely as a representative of the Record Office, and in going to these various places I have been received most cordially. At the Board of State Charities in Indiana, Mr. A. W. Butler, Secretary has coöperated very extensively.

I might say too, that in working in the various states of the Union, and these include

over half of the states, I have been received most cordially by those persons to whom I have gone, and information has been very readily and quickly given.

At the time I was working on the Jukes, the State Commissioner of Prisons and the State Board of Charities in this state (New York) turned their office material over, even the Bertillion measurements of criminals in this state.

Political conditions have had no influence. That has been due to the fact, I think, that I am associated with a private organization.

INDEX

PLATES

Plate 1. The Chromosomes of Man

This chart gives the essential results of a study on human spermatogenesis, made by Professor Theophilus S. Painter, Department of Zoölogy, University of Texas, Austin, Texas. Figures 1 and 2 show that there are 48 chromosomes (24 pairs) in the germ cells (spermatogonia) of a white man, this number including the body labeled "Y." The negro (figs. 3 and 4) shows the same number of chromosomes and the presence of the Y-chromosome. In figures 5 and 6 the chromosomes of the white man and the negro are compared. They are alike in general form and in number. Figure 7 shows the "reduced" chromosome number of man to be 24. Figure 8 shows the sex-chromosomes of man which are of the X–Y type. When such a cell divides, the X-chromosome goes to one pole and the Y-chromosome to the other. This is shown in figure 9, taken from a white man, and in figure 10 which is from negro material. As a result of this, one-half of the sperm will carry an X-chromosome, and one-half will carry a Y-chromosome. Sex determination in man then is simply a matter of which sort of sperm fertilizes the egg. If the sperm carries an X-chromosome, then the resulting offspring is a female, but if the sperm carries a Y-chromosome, a son will result.

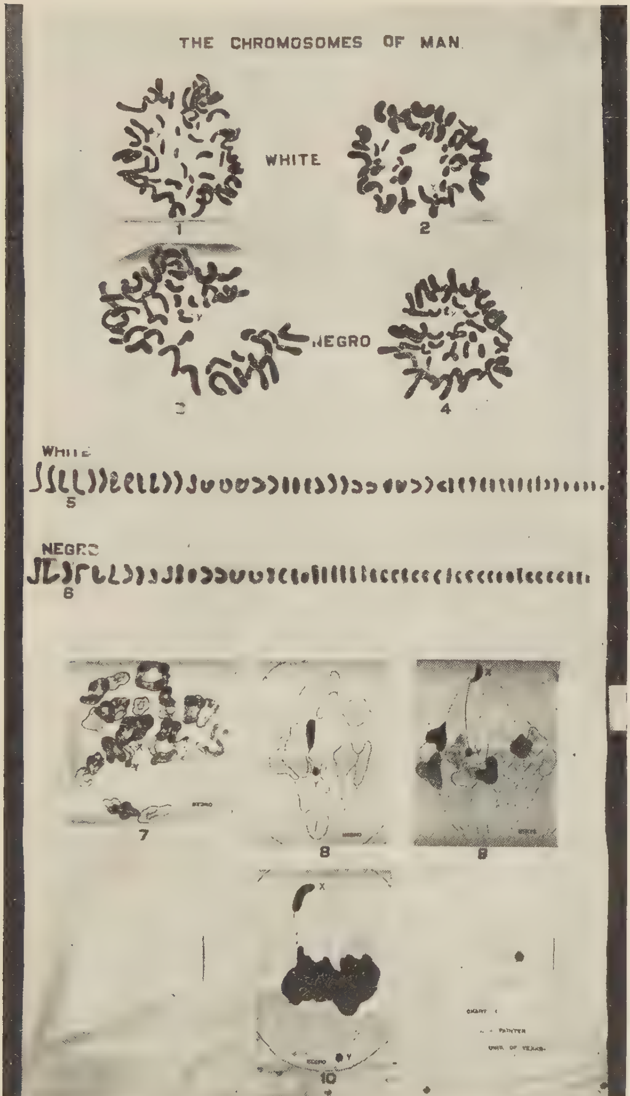

THE CHROMOSOMES OF MAN.
WHITE
NEGRO
1
2
3
4
5
6
7
8
9
10

Plate 2. The Catlin Mark

Inheritance of an unusual opening in the parietal bones. By Dr. William M. Goldsmith, Professor of Biology, Southwestern College, Winfield, Kansas.

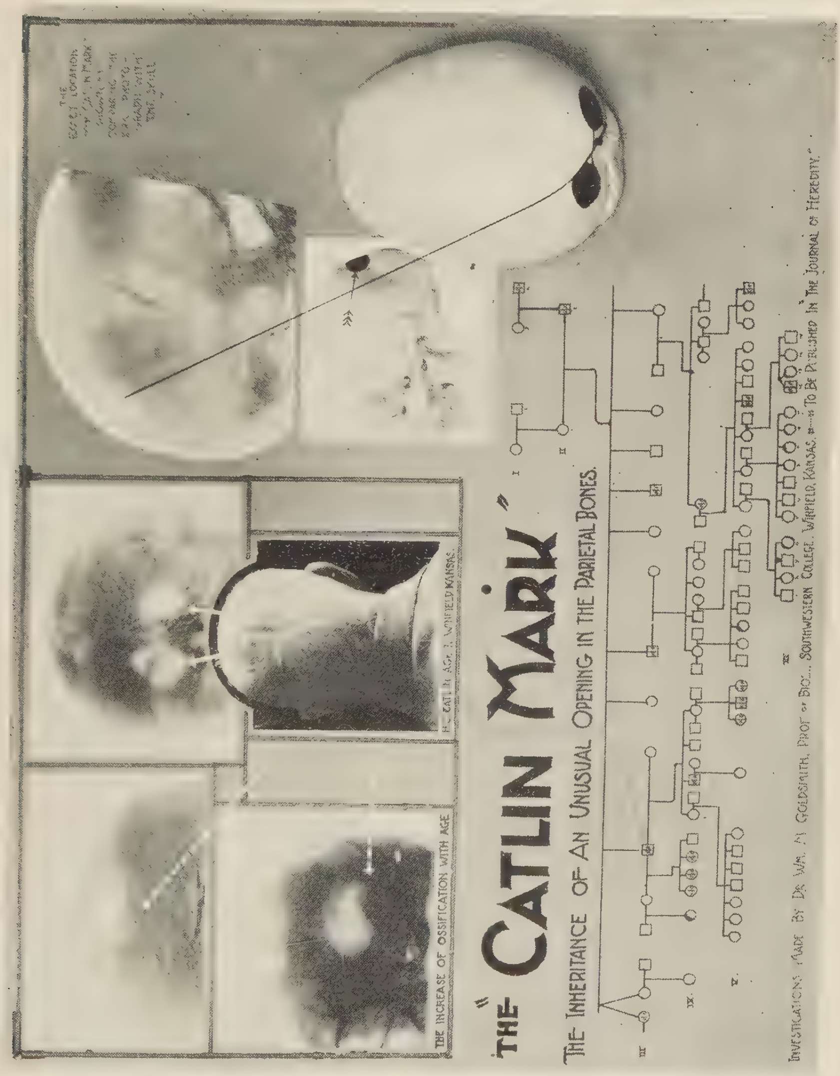

THE INCREASE OF OSSIFICATION WITH AGE
"THE CATLIN MARK"
THE INHERITANCE OF AN UNUSUAL OPENING IN THE PARIETAL BONES.
INVESTIGATIONS MADE BY DR. WM. M. GOLDSMITH, PROF. OF BIO., SOUTHWESTERN COLLEGE, WINFIELD, KANSAS. — TO BE PUBLISHED IN THE JOURNAL OF HEREDITY.

Plate 3. Inheritance of Order of Succession in Development of the Carpal Bones

Charts showing, for children of each of three families, the order of succession of development of the carpal bones, of the wrist. The X-ray photographs were furnished by Dr. Prior of Lexington, Ky. The outline diagrams show the order of development of the bones in each individual. Eugenics Record Office.


6 A
6 B
4 A
4 B
4 C
4 D
6
G. FAMILY
L. FAMILY
5 A
5 B
5 C
5 D
5

Plate 4. Heredity of Longevity

Stereograms showing relation between age of father at death, age of mother at death, and longevity of offspring.

Upper series, left to right:

–20. Persons who died under twenty years. "The stereogram relates to 417 persons who died under twenty years of age. The figures show the percentage having fathers and mothers who died at ages specified. 8.9 per cent had parents who lived to be over eighty years of age."

20–40. Persons who died twenty to forty years of age. "The stereogram relates to 354 persons who died twenty to forty years of age. The figures show the percentage having fathers and mothers, who died at the ages specified. 4.8 per cent had parents who lived to be over eighty years of age."

40–60. "The stereogram relates to 351 persons who died forty to sixty years of age. The figures show the percentage having fathers and mothers who died at the ages specified. 8.1 per cent had parents who lived to be over eighty years of age."

Lower series:

60–80. "The stereogram relates to 333 persons who died sixty to eighty years of age. The figures show the percentage having fathers and mothers who died at ages specified. 18.0 per cent had parents who lived to be over eighty years of age."

80–100. "The stereogram relates to 138 persons who died eighty to one hundred years of age. The figures show the percentage having fathers and mothers who died at the ages specified. 27.5 per cent had parents who lived to be over eighty years of age."

Alexander Graham Bell.

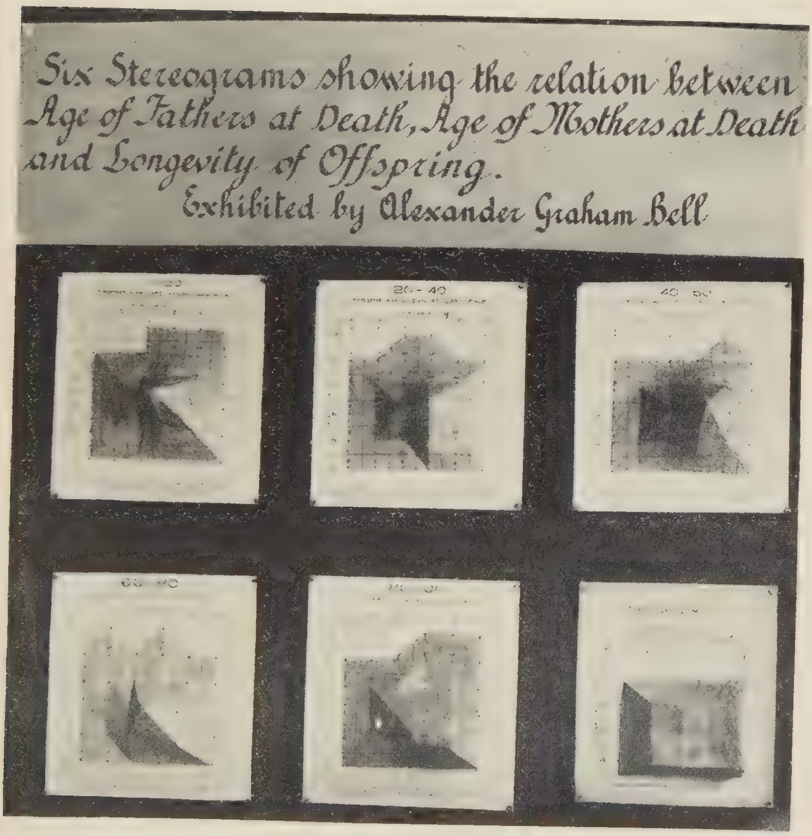

Six Stereograms showing the relation between
Age of Fathers at Death, Age of Mothers at Death
and Longevity of Offspring.
Exhibited by Alexander Graham Bell
20 - 40

PLATE 5. PEDIGREES OF DRAMATIC AND MUSICAL TALENT

(1) Dramatic ability—Kemble family. (2) Musical talent—Bach family. Prepared by the Eugenics Education Society, London, England.

PLATE 5

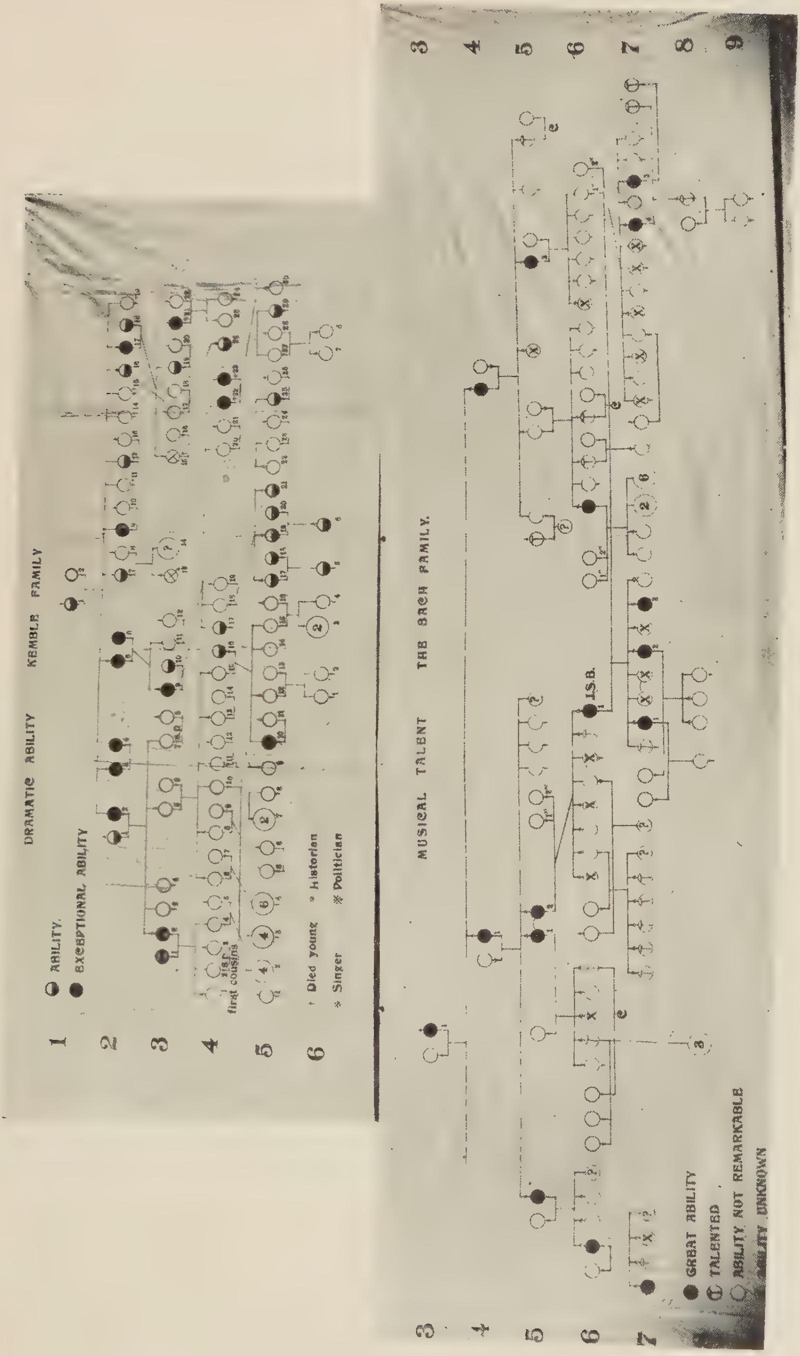

DRAMATIC ABILITY KEMBLE FAMILY
ABILITY
EXCEPTIONAL ABILITY
first cousins
Died young
Historian
Singer
Politician
MUSICAL TALENT THE BACH FAMILY
J.S.B.
GREAT ABILITY
TALENTED
ABILITY NOT REMARKABLE
ABILITY UNKNOWN

Plate 6. Heredity of Musical Ability

These charts, prepared by Dr. Hazel M. Stanton, Eastman School of Music, Rochester, N. Y., are representative of the results obtained in an investigation in the inheritance of specific musical capacities, which covered six family groups, in which one member of each group was known to be conspicuously talented in music. This investigation, initiated in the year 1920, is the beginning of the first research in heredity of talent based on quantitative measurements. Four of the Seashore Measures of Musical Talent, the sense of pitch, the sense of intensity, the senses of time and tonal memory were given individually to members of each family. These measurements were supplemented by qualitative information regarding individual case histories and musical experiences, the latter including musical environment during youth, musical training and education, musical activity, musical interests, and musical memory and imagination.

On each pedigree talent chart one mating and offspring are presented showing the results obtained in the musical measurements, also the ratings assigned for muscial experiences. The results of each of the four measurements are expressed graphically in terms of percentile rank ranging from 0 to 100. A rank of 98 to 100 is very superior, 90 to 97 is superior, 70 to 89 is excellent, 40 to 59 is average, 10 to 29 is poor. The sense of pitch is shown in the upper horizontal section of each individual chart, the sense of intensity in the second section, the sense of time in the third section, tonal memory in the lower section. The ratings of musical experiences are stated in terms of the letter *A*, high rating, the letter *C*, middle rating, and the letter *E*, low rating. At the side of each chart a brief description is given of the musical expression evinced by each individual charted.

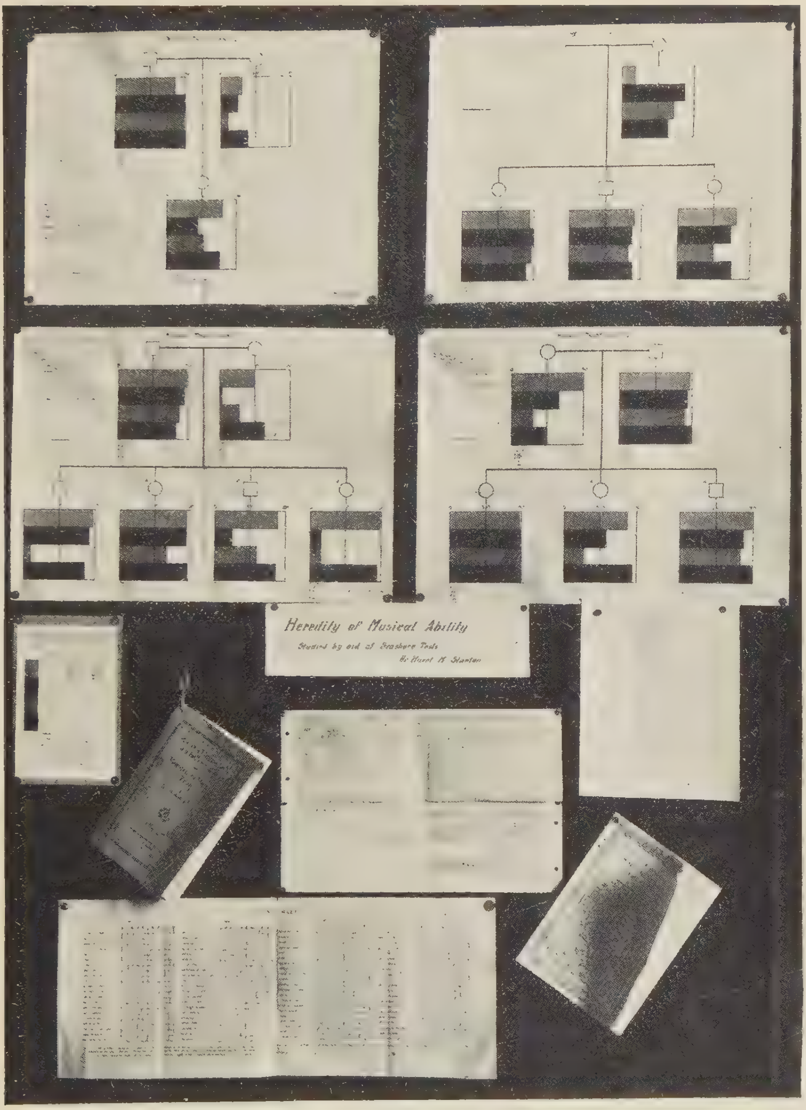

Heredity of Musical Ability

PLATE 7. HEREDITY OF HARELIP AND CLEFTPALATE

Pedigree charts.

Upper: Three families showing harelip inherited without cleftpalate.

Lower: Three families showing harelip and cleftpalate, often both defects in one individual. Eugenics Record Office.

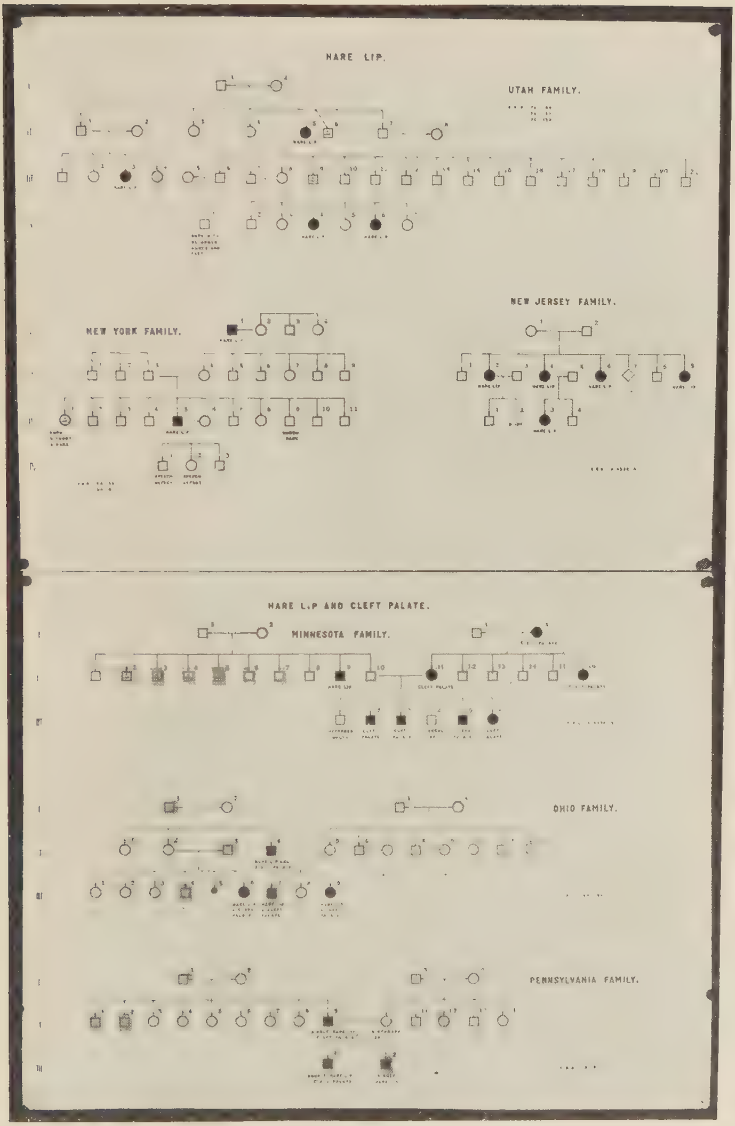

HARE LIP.
UTAH FAMILY.
NEW YORK FAMILY.
NEW JERSEY FAMILY.
HARE LIP AND CLEFT PALATE.
MINNESOTA FAMILY.
CLEFT PALATE
OHIO FAMILY.
PENNSYLVANIA FAMILY.

Plate 8. Inheritance in Epilepsy

Six charts illustrating inheritance of epilepsy. In all charts: *A*, alcoholic; *E*, epileptic; *F*, feebleminded; *I*, insane; *Ne*, neurotic; *S*, syphilitic; *Sx*, sex offender; *W*, nomadic; squares, males; circles, females. Black symbols, defective individuals.

Dr. David F. Weeks, Skillman (New Jersey) Village for Epileptics.


SYPHILIS AND EPILEPSY.
Hysterical
died in infancy
EPILEPSY IN 4 GENERATIONS
EPILEPSY IN 3 GENERATIONS
SEVEN EPILEPTICS DESCENDANT FROM ALCOHOLICS OF THE PERIODIC SPREE TYPE
EPILEPSY AND FEEBLEMINDEDNESS. A FORCED MARRIAGE
"EASY GOING"
PERIODIC SPREES, BEGGAR, ALMSHOUSE INMATE.
MISER
BAD BAD TEMPER TEMPER
INFANTILE CONVULSIONS FAINT. SPELLS

Plate 9. Inheritance of Specific Iso-agglutinins in the Human Blood

The blood serum of certain persons will cause the red blood corpuscles of certain others to stick together (agglutinate) in clumps. Four human blood groups are recognized (I–IV). Their properties are described in the lower right hand chart.

Prepared by Dr. F. L. Reichert, Johns Hopkins University.

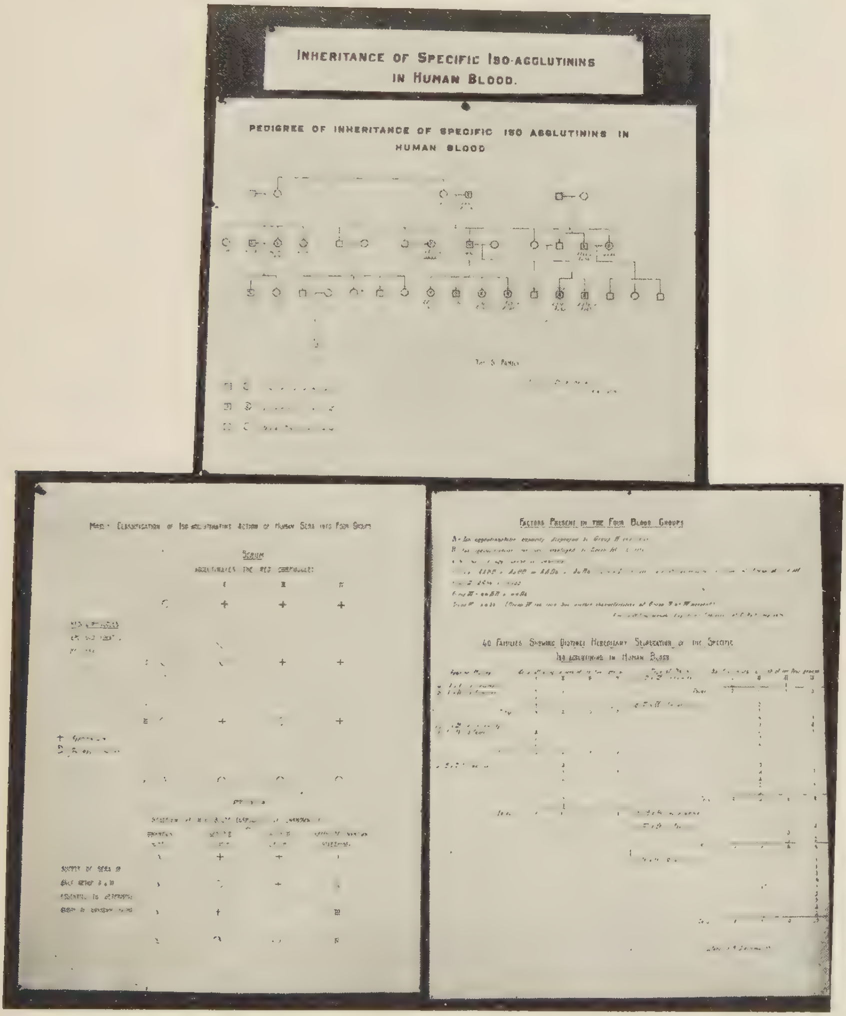

INHERITANCE OF SPECIFIC ISO-AGGLUTININS IN HUMAN BLOOD.
PEDIGREE OF INHERITANCE OF SPECIFIC ISO AGGLUTININS IN HUMAN BLOOD
FACTORS PRESENT IN THE FOUR BLOOD GROUPS

Plate 10. Color Inheritance in Corn

Purple stalk and leaves; kernels of various colors, also tan stalk, leaves and kernels. Seven ears of seven colors of pericarp, ranging from deep purple, crimson, pink, tan, brown, yellow and white, all with the royal purple husk, showing constant husk color with varied colored kernels.

Corn bred and exhibited by Harvey J. Sconce, Plant Breeder, Sidell, Illinois.

Plate 11. Measurement of Physical Traits

Methods of taking measurements, illustrated on a subject. Reading from left to right and from above down:

1. Vertex height. 2. Tragion. 3. Acromion. 4. Radiale. 5. Stylion. 6. Dactylion. 7. Suprasternale. 8. Tibiale. 9. Internal malleolus. 10. Anterior ilio-spinale. 11. Symphysion. 12. Cervicale. 13. Bicristal breadth. 14. Bitrochaner breadth. 15. Iliospinal breadth. 16. Chest breadth. 17. Antero-posterior chest diameter. 18. Sitting vertex height. 19. Sitting suprasternal height. 20. Head length. 21. Head breadth. 22. Tracing skull contours. 23. Measurement over a bathing suit.

Instruments made by Hermann, Zurich.

Pictures by Professor H. H. Wilder, Smith College.

At right, a scale for measuring stature in English and metric systems.

Iowa Child Welfare Research Station.

Plate 12. Measurement of Physical and Mental Traits

Condensed guide to the Binet tests. Method of head measurement. From the Vineland (New Jersey) Training School.


THE BINET TESTS

Plate 13. Measurement of Mental Traits

Mental tests used at Vineland.
Training School at Vineland, New Jersey.

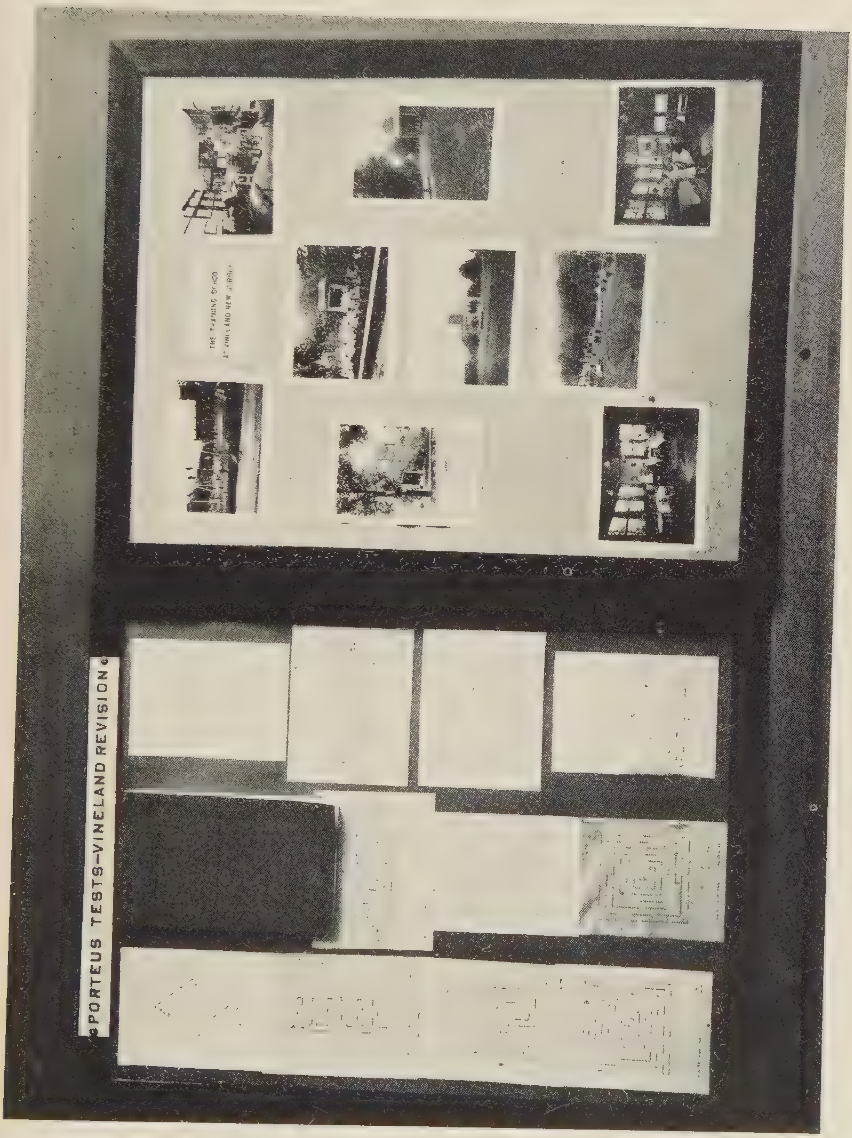

PORTEUS TESTS–VINELAND REVISION

Plate 14. Palm and Sole Prints and Their Inheritance

Left, above. Various sole prints of European-Americans.
Left, middle. Palm prints of mother and two sons. Diversity in one family.
Left, below. Father and son, the latter a complete duplicate of the former.

Four larger charts on right are prints "interpreted," i.e., covered with lines indicative of the individual conditions. These are of duplicate or "identical" twins,—that is, twins that have arisen from a single egg. The general character but not the minutiae are the same in both members of a set.

By Prof. H. H. Wilder, Smith College.

PLATE 15. COMPOSITE PORTRAITURE

Composite photographs largely made by the late Henry P. Bowditch of Boston.

First row: Left upper: 60 Wellesley College students. Left lower: Class of '87, Vassar College. 12 Wends and composite. 12 Portland (Me.) physicians and composite. 12 Saxons and composite.

Second row: College men from Harvard, Amherst, 449 components. Co-composite, Harvard Annex, Smith, etc., 287 components. Harvard Class of 1887, 156 members. 12 Horse-car drivers. General paresis, 8 components (5 men and 3 women), 11 Mathematicians Amherst Class of 1887, 71 components Williams College, 57 components. 16 Naturalists.

Third row: Women's Medical College, 1887, 38 components. Component three members of Bowditch family. 12 Boston Doctors and composite. Mt. Holyoke class of 1887, 47 components. Harvard Annex, 1887, 47 components. Smith, 1887, 38 components.

Fourth row: Horse-car conductors, 12 components. Sheffield Scientific School, Class of 1887. Cornell, 1887, 65 men, 5 women. 30 Members of the National Academy of Science. Melancholia, 8 components. Harvard Faculty, 1887, 38 components.

Bottom row: Upper left: 12 Portland doctors and composite. Lower left: 12 Horse-car drivers, Boston '88, 12 Saxons and composite, 12 Wends and composite, 12 Saxons and composite.

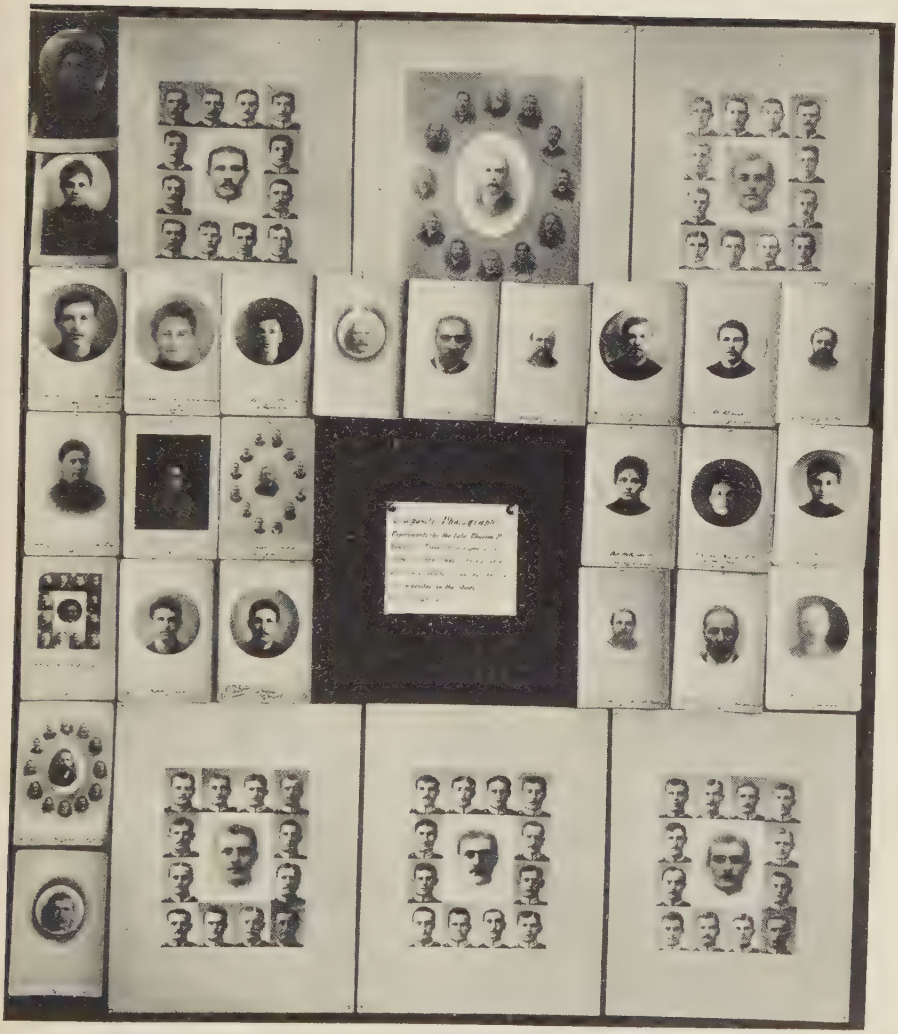


Plate 16. Pedigree of John Burroughs

Family history chart, with three portraits and a life mask, of John Burroughs. Also portraits of brothers, sisters, parents and other close relatives. At the right, two photographs of Burroughs; one of them, his last, taken a few days before his death.

By Harry H. Laughlin, Eugenics Record Office.

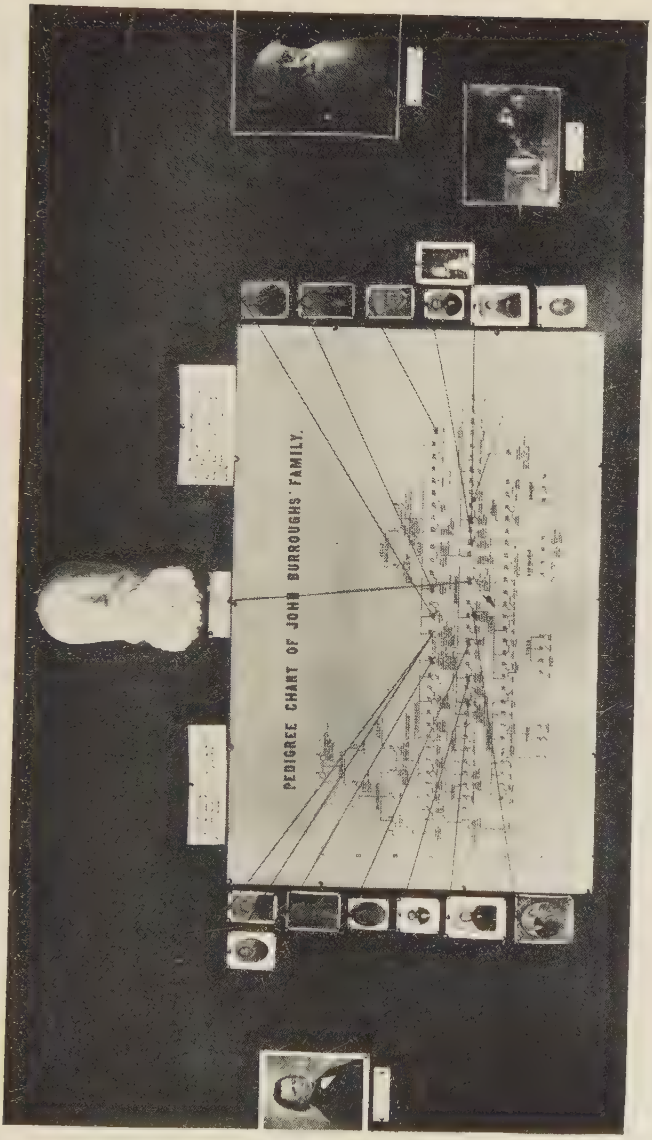

PEDIGREE CHART OF JOHN BURROUGHS' FAMILY.

PLATE 17. PEDIGREE OF THE CAESARS

From the Exhibit of the Eugenics Education Society, London, England

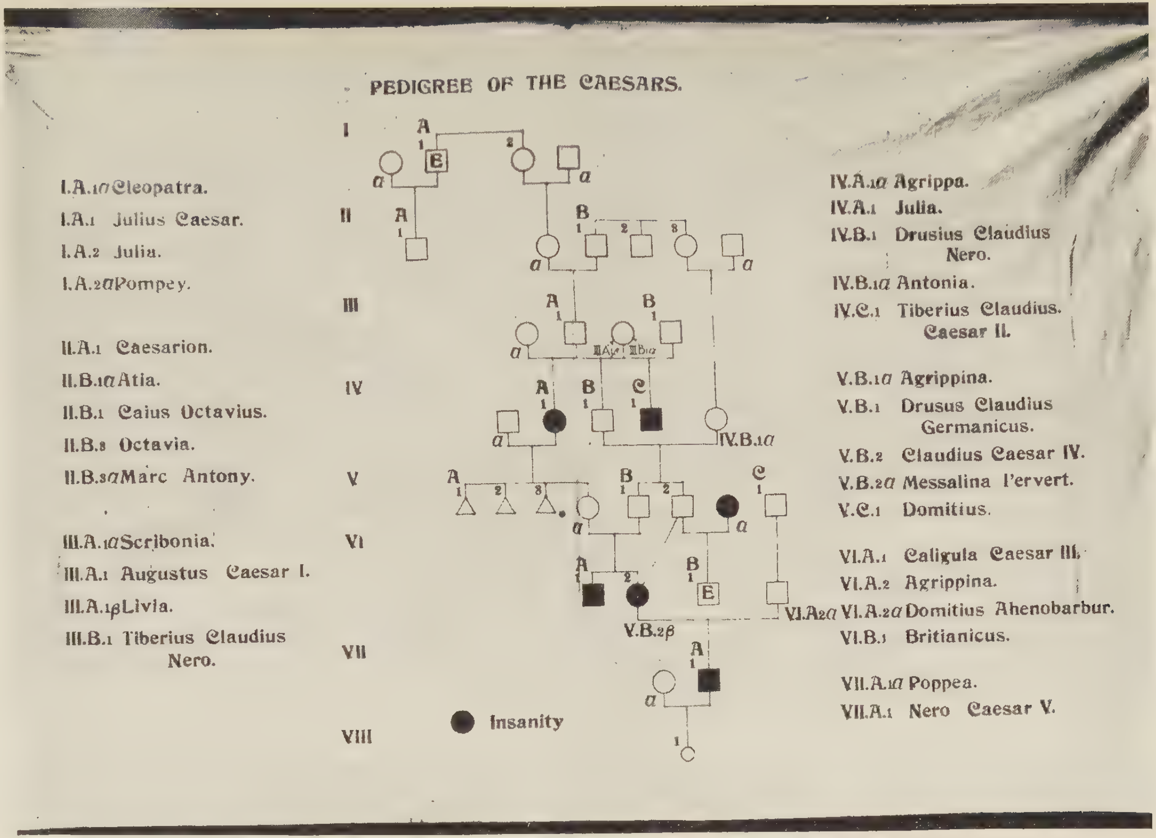

PEDIGREE OF THE CAESARS.
I.A.1a Cleopatra.
I.A.1 Julius Caesar.
I.A.2 Julia.
I.A.2a Pompey.
II.A.1 Caesarion.
II.B.1a Atia.
II.B.1 Caius Octavius.
II.B.3 Octavia.
II.B.3a Marc Antony.
III.A.1a Scribonia.
III.A.1 Augustus Caesar I.
III.A.1β Livia.
III.B.1 Tiberius Claudius Nero.
IV.A.1a Agrippa.
IV.A.1 Julia.
IV.B.1 Drusius Claudius Nero.
IV.B.1a Antonia.
IV.C.1 Tiberius Claudius. Caesar II.
V.B.1a Agrippina.
V.B.1 Drusus Claudius Germanicus.
V.B.2 Claudius Caesar IV.
V.B.2a Messalina Pervert.
V.C.1 Domitius.
VI.A.1 Caligula Caesar III.
VI.A.2 Agrippina.
VI.A.2a Domitius Ahenobarbur.
VI.B.1 Britianicus.
VII.A.1a Poppea.
VII.A.1 Nero Caesar V.
Insanity

Plate 18. The Old Americans and the Tribe of Ishmael

Upper: Physical proportions and physiological characteristics of females as compared with males, among the old Americans. Top line of figures gives the rates of female to male dimension. From Dr. A. Hrdlicka, U. S. National Museum.

Lower: The tribe of Ishmael, by Dr. A. H. Estabrook.

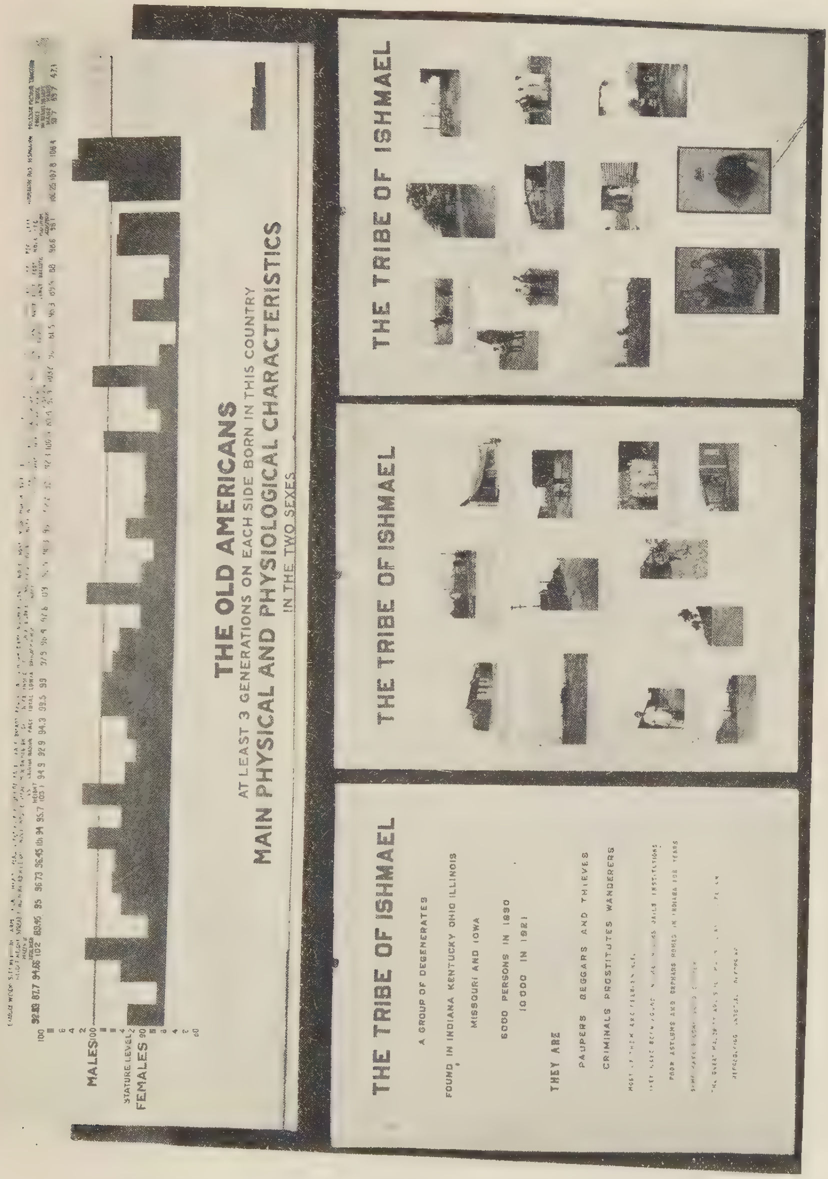

THE OLD AMERICANS
AT LEAST 3 GENERATIONS ON EACH SIDE BORN IN THIS COUNTRY
MAIN PHYSICAL AND PHYSIOLOGICAL CHARACTERISTICS
IN THE TWO SEXES
MALES
STATURE LEVEL
FEMALES
THE TRIBE OF ISHMAEL
THE TRIBE OF ISHMAEL
THE TRIBE OF ISHMAEL
A GROUP OF DEGENERATES
FOUND IN INDIANA KENTUCKY OHIO ILLINOIS
MISSOURI AND IOWA
6000 PERSONS IN 1890
10000 IN 1921
THEY ARE
PAUPERS BEGGARS AND THIEVES
CRIMINALS PROSTITUTES WANDERERS

Plate 19. The Jukes

The Juke charts compare the family as known to Dugdale in 1875 and again to A. H. Estabrook in 1915, forty years later. Dugdale, 1875, while inspecting the county jails of New York State, discovered this family of criminals, prostitutes and paupers, studied their family history and gathered data concerning seven hundred persons descended from "Margaret, called the Mother of Criminals." In 1915 Estabrook studied the same family of people to ascertain the changes in social and mental status which had taken place in the intervening forty years. The charts show the two sets of data, one of course inclusive of the other, comparing the family at the different periods and showing that the Jukes are still a serious burden to the coummunity. A few Jukes have risen from the mire and are now socially adequate persons. Pictures of various members of the family and their living conditions are shown. By A. H. Estabrook.

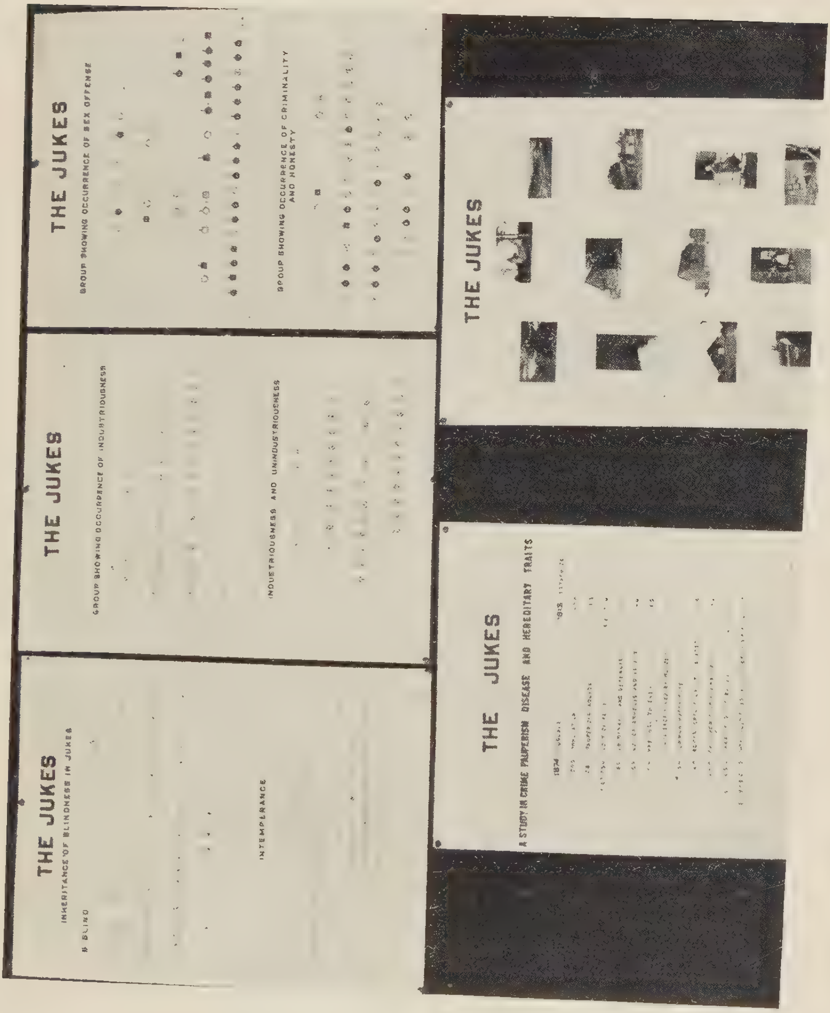

THE JUKES
GROUP SHOWING OCCURRENCE OF SEX OFFENSE
GROUP SHOWING OCCURRENCE OF CRIMINALITY AND HONESTY
THE JUKES
GROUP SHOWING OCCURRENCE OF INDUSTRIOUSNESS
INDUSTRIOUSNESS AND UNINDUSTRIOUSNESS
THE JUKES
INHERITANCE OF BLINDNESS IN JUKES
BLIND
INTEMPERANCE
THE JUKES
THE JUKES
A STUDY IN CRIME PAUPERISM DISEASE AND HEREDITARY TRAITS
1874
1915

PLATE 20. THE NAMS

The Nams are a set of feeble-minded folk living in the northern part of New York state. They are characterized by illegitimacy, prostitution, consanguinity and feeble-mindedness. They number about two thousand persons, practically none of whom has become socially adequate. The majority of the family is still reproducing its own kind of dysgenic folk. The charts show pictures of the folk and their homes and general habitat. A. H. Estabrook, Eugenics Record Office.

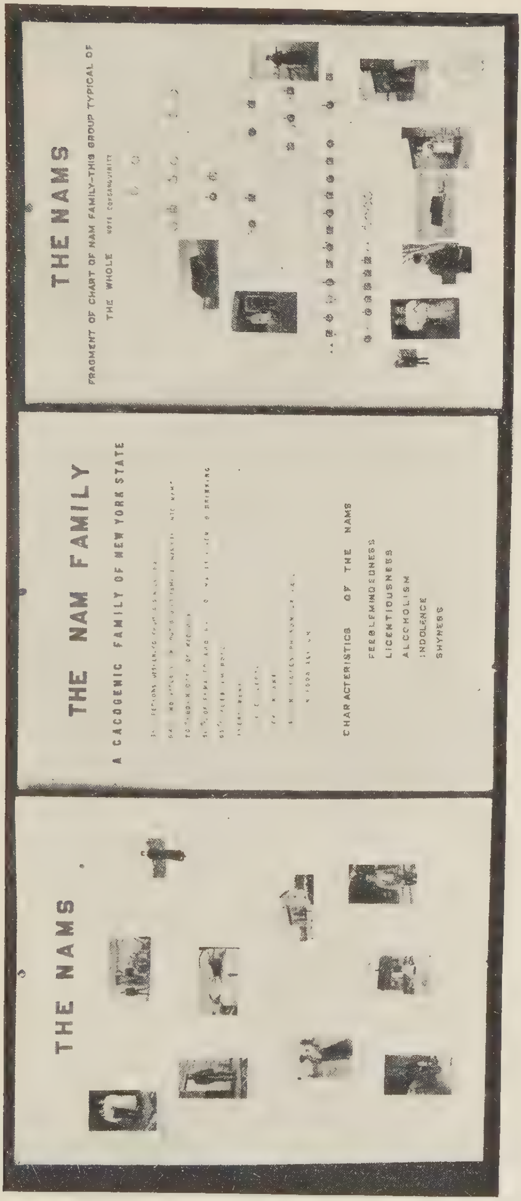

THE NAMS
FRAGMENT OF CHART OF NAM FAMILY—THIS GROUP TYPICAL OF
THE WHOLE
THE NAM FAMILY
A CACOGENIC FAMILY OF NEW YORK STATE
CHARACTERISTICS OF THE NAMS
FEEBLEMINDEDNESS
LICENTIOUSNESS
ALCOHOLISM
INDOLENCE
SHYNESS
THE NAMS

PLATE 21. MENTALITY AND DELINQUENCY

Relation of illegitimacy to parental mentality and infant mortality, also of delinquency to mentality. Children's Bureau, U. S. Department of Labor.

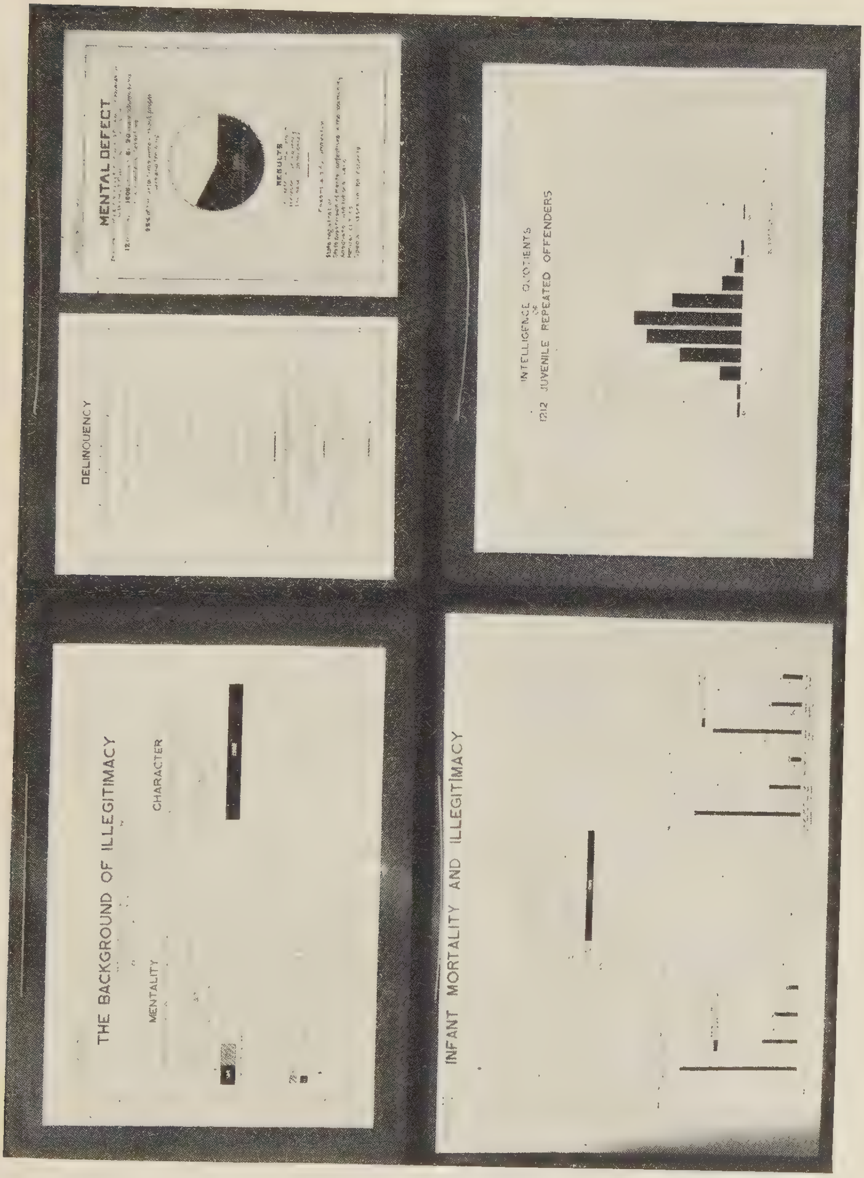

MENTAL DEFECT
RESULTS
DELINQUENCY
INTELLIGENCE QUOTIENTS
OF
1212 JUVENILE REPEATED OFFENDERS
THE BACKGROUND OF ILLEGITIMACY
MENTALITY
CHARACTER
INFANT MORTALITY AND ILLEGITIMACY

Plate 22. The Brains of Criminals

Photographs of criminal brains, showing great variety of forms. Part of exhibit of Massachusetts Department of Mental Diseases, by Dr. Myrtelle M. Canavan.

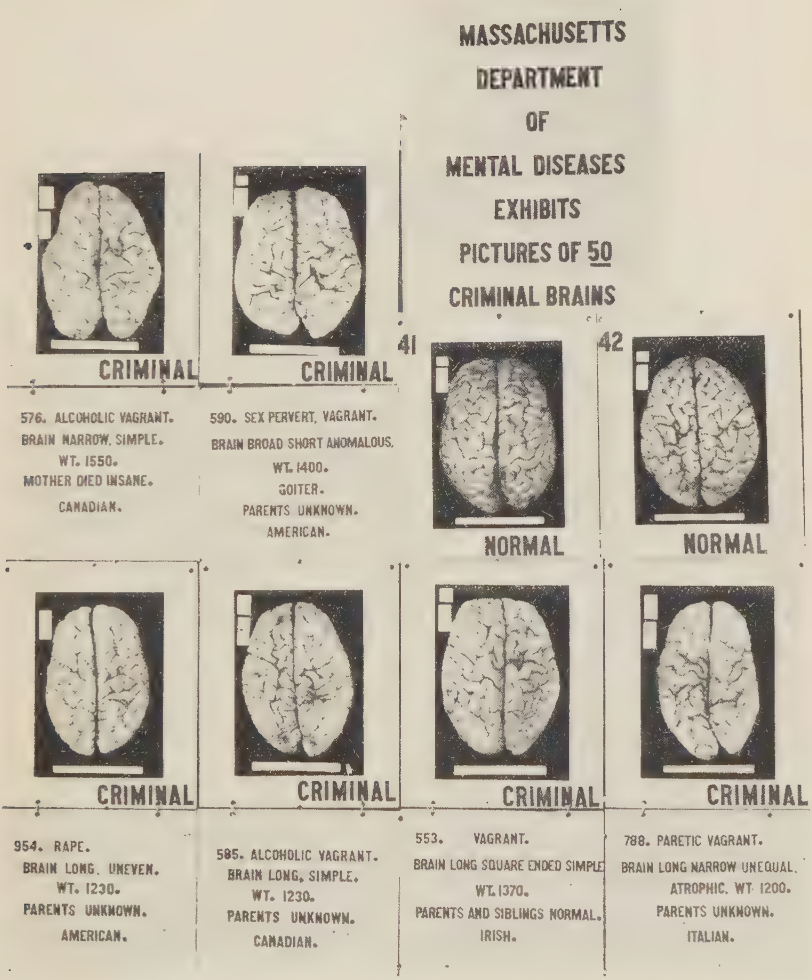
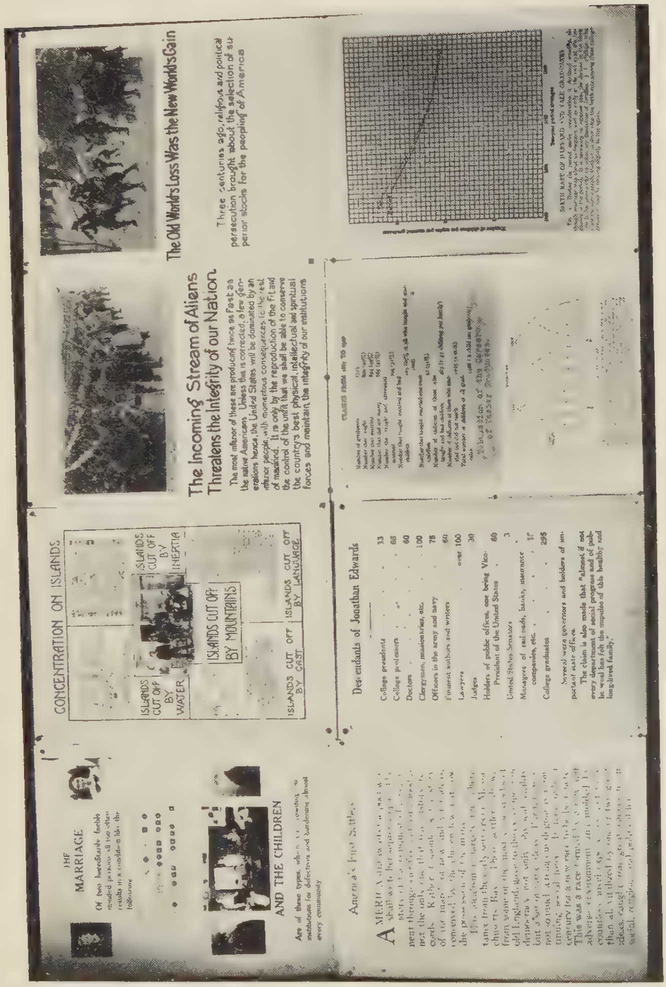

MASSACHUSETTS
DEPARTMENT
OF
MENTAL DISEASES
EXHIBITS
PICTURES OF 50
CRIMINAL BRAINS
CRIMINAL
576. ALCOHOLIC VAGRANT. BRAIN NARROW, SIMPLE. WT. 1550. MOTHER DIED INSANE. CANADIAN.
CRIMINAL
590. SEX PERVERT, VAGRANT. BRAIN BROAD SHORT ANOMALOUS. WT. 1400. GOITER. PARENTS UNKNOWN. AMERICAN.
41
NORMAL
42
NORMAL
CRIMINAL
954. RAPE. BRAIN LONG, UNEVEN. WT. 1230. PARENTS UNKNOWN. AMERICAN.
CRIMINAL
585. ALCOHOLIC VAGRANT. BRAIN LONG, SIMPLE. WT. 1230. PARENTS UNKNOWN. CANADIAN.
CRIMINAL
553. VAGRANT. BRAIN LONG SQUARE ENDED SIMPLE. WT. 1370. PARENTS AND SIBLINGS NORMAL. IRISH.
CRIMINAL
788. PARETIC VAGRANT. BRAIN LONG NARROW UNEQUAL. ATROPHIC. WT. 1200. PARENTS UNKNOWN. ITALIAN.

Plate 23. Marriage and Birth Rate in Relation to Immigration

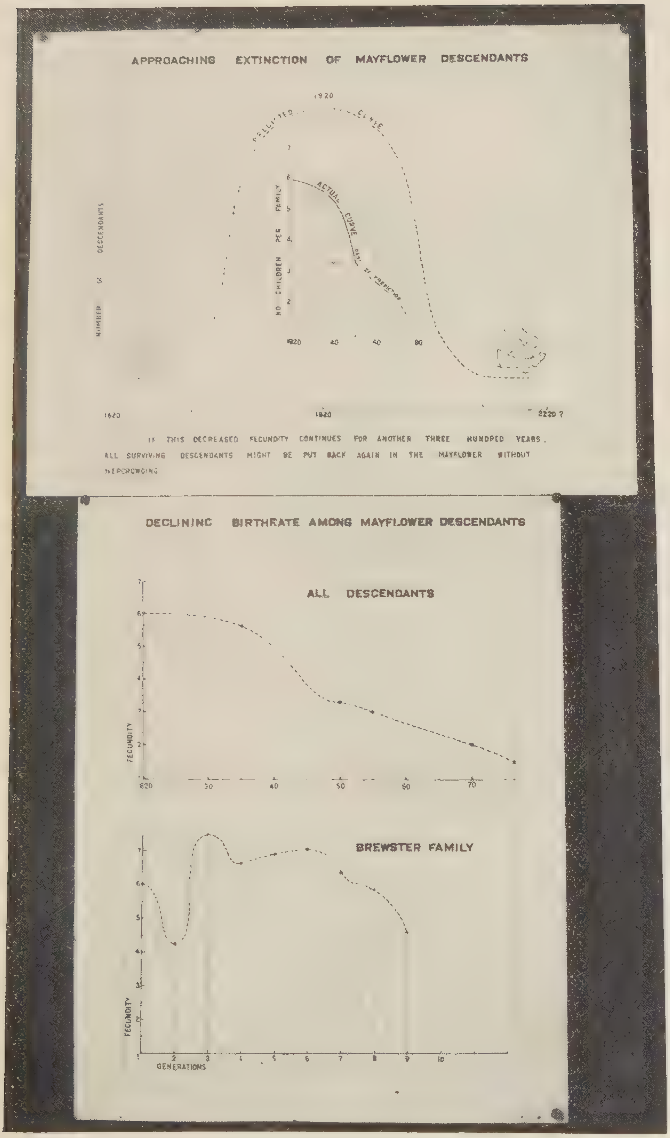
Marriage, fecundity and immigration and their significance for the nation. Charts furnished by the Race Betterment Foundation.



THE MARRIAGE
AND THE CHILDREN
America's First Settlers
CONCENTRATION ON ISLANDS
ISLANDS CUT OFF BY WATER
ISLANDS CUT OFF BY MOUNTAINS
ISLANDS CUT OFF BY INERTIA
ISLANDS CUT OFF BY CAST
ISLANDS CUT OFF BY LANGUAGE
Descendants of Jonathan Edwards
The Incoming Stream of Aliens Threatens the Integrity of our Nation
The Old World's Loss Was the New World's Gain
Three centuries ago, religious and political persecution brought about the selection of superior stocks for the peopling of America

Plate 24. Approaching Extinction of "Mayflower" Descendants

The declining birth rate and its consequences. (1) Approaching extinction of *Mayflower* Descendants. (2) Declining birthrate among *Mayflower* Descendants. (3) Varying fecundity of the Brewster family. Eugenics Record Office.


APPROACHING EXTINCTION OF MAYFLOWER DESCENDANTS
PREDICTED CURVE
ACTUAL CURVE
NUMBER OF DESCENDANTS
NO. CHILDREN PER FAMILY
1620
1920
2220 ?
IF THIS DECREASED FECUNDITY CONTINUES FOR ANOTHER THREE HUNDRED YEARS, ALL SURVIVING DESCENDANTS MIGHT BE PUT BACK AGAIN IN THE MAYFLOWER WITHOUT OVERCROWDING
DECLINING BIRTHRATE AMONG MAYFLOWER DESCENDANTS
ALL DESCENDANTS
FECUNDITY
BREWSTER FAMILY
FECUNDITY
GENERATIONS